Adaptation to Climate Change in Pastoral and Agropastoral Systems of Borana, Southern Ethiopia

by

Nega Emiru Debela
B.Sc. (Dryland Agriculture and Natural Resources), Mekelle University and M.Sc. (Agriculture), Haramaya University

School of Land and Food

Submitted in fulfilment of the requirements for the Degree of Doctor of Philosophy

University of Tasmania, February 2017

DECLARATION OF ORIGINALITY

I hereby declare that this thesis does not contain any material which has been accepted for a degree or diploma by the University of Tasmania or any other institution. To the best of my knowledge, this thesis contains no material previously published or written by another person except where due reference is made in the text of this thesis. This thesis does not contain any material that infringes copyright.

AUTHORITY OF ACCESS

This thesis may be made available for loan. Copying of any part of this thesis is prohibited for two years from the date this statement was signed; after that time limited copying and communication is permitted in accordance with the Copyright Act 1968.

STATEMENT ON PUBLISHED WORK

The publishers of the papers comprising chapters 3, 4 and 5 hold the copyright for that content, and access to the material should be sought from the respective journals. The remaining non-published content of the thesis may be made available for loan and limited copying and communication in accordance with the Copyright Act 1968.

February 2017

Nega Debela

Statement of co-authorship

The following people and institutions contributed to the publication of work undertaken as part of this thesis:

Nega Debela, School of Land and Food, University of Tasmania (Candidate)

Caroline Mohammed, School of Land and Food, University of Tasmania (Supervisor)

Kerry Bridle, School of Land and Food, University of Tasmania (Co-Supervisor)

David McNeil, School of Land and Food, University of Tasmania (Co-Supervisor)

Ross Corkrey, Tasmanian Institute of Agriculture (TIA), University of Tasmania (Research Advisor)

Author details and their roles:

Paper 1: Perception of climate change and its impact by smallholders in pastoral/agropastoral systems of Borana, south Ethiopia. SpringerPlus 2015, 4: 236

Located in Chapter 3

Nega Debela has made a major contribution (70%) through primarily designing and conducting the farm household survey, analysing the data and writing the initial draft of the manuscript. Caroline Mohamed (12%), Kerry Bridle (8%), Ross Corkrey (5%) and David McNeil (5%) contributed to the survey design, analysed the data, and edited the manuscript.

Paper 2: Options for climate change adaptation in the pastoral and agropastoral systems of Borana, southern Ethiopia (Submitted to Climate and Development)

Located in Chapter 4

Nega Debela has made a major contribution (65%) through primarily designing and conducting the farm household survey, analysing the data and writing the initial draft of the manuscript. Caroline Mohamed (20%) and David McNeil (15%) contributed to the survey design, analysed the data, and edited the draft manuscript.

Paper 3: Enhancing the role of indigenous rural institutions in adaptation to climate change in Borana pastoral and agropastoral systems, South Ethiopia (Submitted to Regional Environmental Change)

Located in Chapter 5

Nega Debela has made a major contribution (65%) through primarily designing and conducting the surveys required for the study, analysing the data and writing the initial draft of the manuscript. Caroline Mohamed (20%), Kerry Bridle (10%) and David McNeil (5%) contributed to the survey design, analysed the data, and edited the draft manuscript.

We the undersigned agree with the above stated "proportion of work undertaken" for each of the above published or submitted peer-reviewed manuscripts contributing to this thesis.

Nega Debela, School of Land and Food, University of Tasmania (Candidate)

February 2017

Assoc. Prof. Caroline Mohammed, School of Land and Food, University of Tasmania (Supervisor)

February 2017

Kerry Bridle, School of Land and Food, University of Tasmania (Co-Supervisor)

February 2017

Ross Corkrey, Tasmanian Institute of Agriculture (TIA), University of Tasmania (Research Advisor)

February 2017

David McNeil, School of Land and Food, University of Tasmania (Co-Supervisor)

February 2017

Publications and communications

Journal articles:

1. Nega Debela, Caroline Mohammed, Kerry Bridle, Ross Corkrey and David McNeil (2015) Perception of climate change and its impact by smallholders in pastoral/agropastoral systems of Borana, south Ethiopia. SpringerPlus 4: 236

2. Nega Debela, Caroline Mohammed and David McNeil (2017) Options for climate change adaptation in the pastoral and agropastoral systems of Borana, southern Ethiopia (Submitted to Climate and Development)

3. Nega Debela, Caroline Mohammed, Kerry Bridle and David McNeil (2017) Enhancing the role of indigenous rural institutions in adaptation to climate change in Borana pastoral and agropastoral systems, South Ethiopia (Submitted to Regional Environmental Change)

Conference proceedings:

1. ‘‘Exploring adaptation to climate variability and change in Ethiopia: the case of pastoral systems in the Borana lowlands’’, Sharing Excellence in Research (SEiR), Annual Graduate Research Conference, 1 - 2 September 2011, University of Tasmania, Hobart, Australia.
2. ‘‘Adaptation to climate change in the Borana pastoral/agropastoral systems, south Ethiopia: Options, barriers and institutions’’, a paper accepted for presentation at African Symposium on Climate Change Adaptation (ASCCA 2016) 21 - 23 February 2016, Addis Ababa, Ethiopia.

STATEMENT OF ETHICAL CONDUCT

The research associated with this thesis abides by the international and Australian codes on human and animal experimentation, the guidelines by the Australian Government's Office of the Gene Technology Regulator and the rulings of the Safety, Ethics and Institutional Biosafety Committees of the University.

February 2017

Nega Debela

Abstract

Climate change is cited as one of the greatest environmental challenges facing agricultural systems in the developing world. In particular, smallholder farming systems in dryland ecosystems are considered most vulnerable due to their high dependence on rain-fed production and weak adaptive capacity. The Borana pastoral and agropastoral communities of the arid and semi-arid Ethiopian lowlands studied in this thesis are among those severely and frequently affected due to changing climatic conditions such as drought. The vulnerability of these farming communities is mainly attributed to a high degree of dependence on rainfed farming and inadequate responses to climate-induced risk and uncertainty.

This study took a novel and urgently required approach to understanding these inadequate responses of the Borana pastoral and agropastoral communities. It focused on specifically exploring the local context to what motivates adaptation responses under the traditional rainfed agricultural system. The study is comprised of three interrelated components investigating 1) smallholder perception of climate change, 2) climate change adaptation measures adopted by the Borana pastoral and agropastoral communities and barriers to successful adaptation, and 3) the role of indigenous institutions in the Borana in facilitating agricultural adaptation. Qualitative and quantitative study approaches were used, and various data collection methods were employed including farm household surveys, key informant interviews, focus group discussions, secondary data collation and expert consultations.

A psychometric approach was used to explore smallholder perception of climate change over a 20-year study period (1992-2012). Interview results from farm household surveys conducted in 5 districts, 20 pastoral/agropastoral associations and 480 farm households showed an overwhelming awareness by smallholders of climate change, particularly seasonal changes in rainfall, drier conditions and more extreme events. The level of their perception in terms of extent of climate change and its impact on local agriculture was affected by various farm and household attributes including age, education level, livestock holding, and access to climate information and extension services. Household size, production system, farm and non-farm incomes did not significantly affect perception levels. Changes in climate were attributed to a diverse range of biophysical, deistic and anthropogenic causes.

A Pressure-State-Response (PSR) analytical framework was used to analyse climatic pressures and smallholder responses to climate-induced stresses and their impact. Although the majority of smallholders were highly aware of climate change and its associated impact on their livelihoods, they only employed a variety of short-term resilience and transitional

adaptive measures that primarily includes adjusting farming practices and diversifying into non-pastoral livelihoods. Shortage of financial resources, inadequate technical support (including appropriate climate information and understanding) and limited policy support appear to seriously impede local adaptive capacity and prescribe routes for adaptation.

The role of indigenous institutions in enhancing adaptive capacity and facilitating climate change adaptation for smallholders and local communities was assessed. Institutional leaders were interviewed and a thematic analysis approach was used to analyse data generated from the key informant interviews. Results indicated that indigenous institutions have and could play key roles in supporting local community-based adaptation through: 1) regulating access to common-pool resources required for adaptation, 2) facilitating post-shock livelihood recovery, and 3) providing traditional climate forecast and early warning systems. This enabling role of indigenous institutions is seriously waning due to misguided development approaches that affect the traditional land tenure systems and disrupt local resource governance.

In summary, this thesis indicates that the agricultural systems of the Borana remain highly vulnerable to climate change and its impacts; adaptation goals only embrace short-term resilience and transitional changes whereby any major changes to the system are avoided. The development of more successful adaptive strategies requires a better understanding of the adaptive environment (as explored in this thesis) and promoting endogenous approaches that integrate indigenous institutions in development and build on local resources in order to complement external support.

Keywords: adaptation, agricultural systems, barriers, climate change, institutions, options, pastoralism/agropastoralism, perception, vulnerability

Acknowledgements

The completion of my PhD study has been a long learning path for which a number of people made significant contributions. They all deserve my appreciation, and I would like to take this opportunity to extend my gratitude for their support and encouragement.

I express my gratitude to my supervisors Associate Prof Caroline Mohammed, Prof Holger Meinke, Dr. Kerry Bridle, Dr. Peat Leith, and Prof David McNeil, as well as my research advisor Dr. Belay Simane for their much-valued guidance and encouragement throughout my PhD study. I also wish to thank Dr. Ross Corkrey who provided invaluable statistical support during the design of the survey and analysis of the empirical data and Dr. Alieta Eyles for assisting me with the writing of this thesis.

I would like to thank the University of Tasmania (UTAS) for hosting me as a PhD student and for offering me financial support by the award of an International Postgraduate Research Scholarship (IPRS). In particular, I am indebted to the School of Land and Food (SLAF) for its top-up scholarship plus financial and administrative support related to my fieldwork in Ethiopia.

I would like to acknowledge the Borana smallholders for their willingness to devote their precious time in responding to questions raised in individual and household interviews during the fieldwork. The information collected during both the formal interviews and informal discussions was critical in addressing the formulated research questions of this study. In addition, I am grateful to the enumerators, Jarso Duba, Aden Ali, Mekole Denboba, Gutu Daka, Ibrahim Jitu, Bantayehu Muluneh and Golicha Doyo, who were involved in the farm household interviews during the fieldwork in Ethiopia.

My friends Megersa Walo, Jara Bekele, Degefe Tibebe, Endalkachew Kissi, Shiferaw Mulugeta, Assefa Nuru, John Otto, Ethel Kissakye and Mohamed Ibrahim all deserve special thanks for their constant encouragement and social contribution during my candidature. Life would have been more difficult without their friendly and kind support. I am also thankful to fellow PhD candidates Mathew Wilson, Adrian Hunt and Marek Matuszek for their kind support and helpful advice during difficult times at school. Last but not least, I am thankful to my family members Abebe Tadese, Belay Motuma, Kumela Kassaye, Adugna Debela and Yimenyushal Kassaye for their constant encouragement and support in the course of this study.

Table of Contents

List of figures

List of tables

List of acronyms

AIL:	Adaptation, institutions and livelihood
CCA:	Cultural-consensus analysis
CSA:	Central Statistical Authority
FAO:	Food and Agriculture Organization
FDRE:	Federal Democratic Republic of Ethiopia
GDP:	Gross Domestic Product
GHGs:	Greenhouse Gas
IPCC:	Intergovernmental Panel on Climate Change
ITCZ:	Inter Tropical Convergence Zone
MNL:	Multinomial logistic
MoA:	Ministry of Agriculture
MoARD:	Ministry of Agriculture and Rural Development
NMA:	National Meteorology Organization of Ethiopia
OR:	Odds ratio
PSNP:	Productive safety-net programme
PSR:	Pressure-state-response
SLAF:	School of Land and Food
TLU:	Tropical Livestock Unit
UNEP:	United Nations Environment Programme
USD:	United States Dollar
UTAS:	University of Tasmania
WMO:	World Meteorological Organization

Glossary of terms

Adaptation	The process of adjustment to actual or expected climate and its effects in human and natural systems in order to moderate or avoid harm or exploit beneficial opportunities.
Adaptation option	An adaptive measure adopted by individuals, farm households, communities, their institutions and other actors to avoid or reduce adverse impact on agriculture and livelihoods, and exploit beneficial opportunities from climate change.
Adaptation barrier	Obstacle or impediment that limits adaptive capacity and agricultural adaptation outcomes.
Adaptive capacity	The combination of strengths and resources available to rural communities and their institutions that can be used to undertake successful agricultural adaptation. The ability to adapt to and cope with climate change impacts is a function of wealth, technology, information, skills, infrastructure, institutions, equity, empowerment, and the ability to spread risk.
Climate change	A change in the state of the local climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties often affecting livelihood and that persists for an extended period, typically decades or longer.
Indigenous institutions	Locally established social structures, their customary laws and traditional knowledge that are relevant to agricultural adaptation in Borana farming systems.
Vulnerability	In the context of climate change and farming communities, the propensity or predisposition to be adversely affected due to climate change and its impacts - can be further categorized as biophysical and socioeconomic vulnerability.

Chapter 1: General introduction

1.1 Background

Climate change has been defined as a long-term shift in weather conditions (temperature, rainfall, wind and other climate indicators) which can involve both changes in average conditions and changes in variability, including extreme events (Warren and Lemmen, 2014). Alternatively, the Intergovernmental Panel on Climate Change (IPCC) (2014) defines climate change as ‘‘… a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.’’ The evidence gathered by IPCC (2014) shows that warming of the climate system is unequivocal, as corroborated by meteorological observations including increases in global mean air and ocean temperatures, changing rainfall patterns, widespread melting of snow and ice, and a rising global average sea level (IPCC, 2007b). In this era of Anthropocene, such changes have significant practical implications for human/natural systems and sustainable development.

There is increasing evidence that suggests significant changes in climate are taking place throughout the different regions of the world. Land masses are warming faster than oceans, and it is very likely that all of Africa will warm during this century and the level of warming is very likely to be greater than the global average (IPCC, 2007a). Processes or activities that cause climate change are generally referred to as climate forcing processes (Rosenzweig et al., 2008; Hansen et al., 2012). The major external climate forcing processes are variations in the amount of energy received from the sun and variations in the earth’s orbit around the sun (Warren and Lemmen, 2014). The internal climate forcing processes include effects of oceans, continental drift, atmospheric processes, water cycle, clouds, ice and snow, land surfaces, volcanic eruptions and man-made processes (mainly industrial and agricultural). IPCC (2014) indicates that there is a 95% certainty that humans are the main cause of the current global warming trend with recent anthropogenic emissions of greenhouse gases (e.g. CO_2, CH_4, N_2O) and their atmospheric concentrations being the highest in human history. The human influence on the climate system is predicted to increase during this century and beyond (IPCC, 2014).

Climate change is considered as one of the major environmental problems humanity faces in the twenty-first century (IPCC, 2014). Climate change has increasingly been recognized to cause widespread challenges to and impacts on natural and human systems across all continents and oceans. In response to this concern, the IPCC was set up in 1988 by the World

Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) with the aim to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation (IPCC, 2014). IPCC published their first assessment report in 1992, and since then, a further four reports have been published providing critical information on some of the key issues in relation to climate change (IPCC, 2014).

Given that farming activities directly depend on climatic factors, agricultural production areas around the world are predicted to experience a new era of risk and uncertainty in water availability, food security and incomes including shifts in the production areas of food and non-food crops (IPCC, 2014). Even small amounts of global warming will reduce crop yields and trigger higher yield variability in low-latitude world regions (IPCC, 2014).

1.2 Climate change and its impact on African agriculture

Africa has already experienced an increasingly warming trend and a higher frequency of extreme events such as drought and flood over the last 50 to 100 years (IPCC, 2014) and the impact of climate change into the 21st century will only amplify existing stresses to agriculture. Climate projections indicate that when compared to the 20th century, mean annual temperature rise is likely to exceed 2 °C (IPCC, 2013, 2014). It is likely that land temperatures over Africa will rise faster than the global land average, particularly in the more arid regions, and that the rate of increase in minimum temperatures will exceed that of maximum temperatures (IPCC, 2014).

The impact of climate change on precipitation is predicted to vary between African regions. North Africa and the south-western parts of South Africa will likely face a reduction in precipitation by the end of the 21st century (IPCC, 2014). However, there is uncertainty in projected rainfall change in the mid- and late 21st century over sub-Saharan Africa (IPCC, 2014). For the past four decades, the average annual temperature in Ethiopia has been increasing by 0.37 ºC every ten years, which is slightly lower than the average global temperature rise. Future temperature projections of the IPCC mid-range scenario show that the mean annual temperature will increase in the range of 0.9 to 1.1 ºC by 2030, in the range of 1.7 to 2.1 ºC by 2050, and in the range of 2.7 to 3.4 ºC by 2080 in Ethiopia compared to the 1961 to 1990 normal (Aragie, 2013).

IPPC (2014) states that droughts will intensify in the eastern and southern African regions as a result of expected reduction in precipitation and/or increased evapotranspiration. It is stated that in regions of high or complex topography such as the Ethiopian Highlands,

downscaled projections indicate likely increases in rainfall and extreme rainfall by the end of the 21st century. Determining long-term rainfall trends in Ethiopia is challenging due to strong seasonality and wide inter-annual and decadal variation (Riddle and Cook, 2008). The authors highlighted that marked seasonality is mainly driven by the migration of the Inter-Tropical Convergence Zone (ITCZ). Rainfall events are also negatively correlated with El Nino events which are in turn associated with the basin-wide heating of the Indian Ocean found to the east and south-east of the country (Zaroug et al., 2014). In some parts of Ethiopia, the long-term annual rainfall is non-uniform but has generally shown a declining trend though this may vary depending on which period of time and region is used for analysis (Bewket and Conway, 2007; McSweeney et al., 2008). Large negative main season (June to September) rainfall anomalies, frequently being lower than the long-term average, have been observed during the second half of the 20th century (Seleshi and Zanke, 2004). In addition, evidence by Conway and Schipper (2011) suggests that the spring and winter seasons of the country have shown increases in rainfall amount while the summer and fall have been associated with declining rainfall trends.

Climate projections indicate that the length of growing season in Africa will most likely get shorter putting pressure on crop production systems. This is expected to significantly reduce yield for major cereal crops and negatively impact food security and farm income in the region. Yield losses in the mid 21st century are estimated to range from 18% for the southern African region to 22% aggregated for sub-Saharan Africa while South Africa and Zimbabwe expected to face yield loss in excess of 30% (Zinyengere et al., 2013; IPCC, 2014). For instance, yield loss for maize which is a major and staple cereal crop in the region is projected to decline by an average of 18% in Republic of South Africa (Zinyengere et al., 2013). By 2050, Thornton et al. (2009) predict major livelihood transitions from crop dominated mixed crop-livestock systems to livestock-based farming in the mid-altitude regions of eastern and south-eastern Africa. This shift is mainly attributed to the increasing unreliability of seasonal climate conditions mainly rainfall patterns (Jones and Thornton, 2009).

Seventy percent of the African population rely on natural resources for agricultural production making Africa one of the world's most vulnerable regions to climate change (Downing, 1997; Kurukulasuriya et al., 2006; Di Falco et al., 2012). Much of the agriculture sector in Africa operates under dryland and marginal production conditions with high intra- and inter-seasonal climate variability, and recurrent droughts and floods. As such, climate

change is arguably the principal risk factor affecting the long-term economic viability of its smallholder farmers who predominantly depend on rainfed farming.

1.3 Climate change adaptation

Pelling (2011) makes a straight forward definition of adaptation as a response to a perceived risk or opportunity including environmental stresses such as climate change. In its simplest and generic form adaptation refers to both the process of adapting and the condition of being adapted (Smit et al., 1999). However, the term adaptation has specific interpretations in particular disciplines. For example, adaptation in ecology refers to change by which an organism or species becomes fitted to its environment (Smit et al., 2000); whereas in the social sciences, adaptation refers to the adjustments by individuals and the collective behaviour of socioeconomic systems (Pelling, 2011). The complexity in the definition of adaptation however comes with distinguishing different adaptive actors (such as social groups, economic sectors, etc) and the interactions that may take place between these actors. For instance, Clarke (2009) argues that human beings tend to adapt to poverty by suppressing their wants, hopes and aspirations instead of attempting to change the overarching social and economic structures that constrain their life chances.

Adaptation is one of the key policy responses related to climate change. In its simplest form, IPCC (2014) defined adaptation to climate change as ‘‘… the process of adjustment to actual or expected climate and its effects.’’ In this study, as we investigate human adaptation, we define climate change adaptation as any adjustment to actual or anticipated change in climate change (be it natural or man-made) and its effects to reduce or avoid negative impacts or make use of beneficial opportunities. Adaptation options are defined as an array of appropriate measures and strategies that are available to address the adaptation needs of people involved (Noble et al., 2014). The definition carries the essence of availability and appropriateness of options for use by those in need of adaptation to achieve the desired outcome. Adaptation options in this paper case could be any spontaneous or planned adaptive measures adopted by individuals, farm households, communities, their institutions and other partners in order to moderate adverse impacts and exploit beneficial opportunities due to climate change with a focus in agriculture and rural settings.

Climatic conditions for which adaptation can be considered as a response are categorized into three temporal categories. These are, 1) long-term changes in means or norms, 2) inter-annual or decadal variability, and 3) isolated extreme events or catastrophic weather conditions such as floods, droughts or storms (Smit et al., 1999). The three climate stimuli are

interdependent such that extreme events are part of variability, which is an inherent feature of a changing climate (Pelling, 2011). The mean conditions are the central tendencies of a distribution of conditions which vary from year to year, and are the focus of climate change studies. Thus any adaptation should define the climate stimulus or question of 'what to adapt to', and adaptation to climate change should also consider climate variability through which climate change is experienced.

Agricultural adaptation embraces responses to all three categories of climatic conditions i.e. changes in long-term mean conditions, but also changes in interannual variations in local growing season and magnitude/frequency of extreme events (Smit et al., 1999; Smit and Skinner, 2002; IPCC, 2013). The agricultural sector often contributes to climate change through being responsible for the release of greenhouse gases (GHGs) such as nitrous oxide and methane into the atmosphere (Almås et al., 2011; IPCC, 2014). Trade-offs between adaptation and mitigation (efforts to reduce or prevent the emission of greenhouse gases) are often inevitable in agricultural systems.

Agricultural adaptation, whether autonomous or planned, takes place at different spatial scales including field, farm, village, region and national levels with short to long-term adaptation goals (Smit et al., 2000). While adaptation processes remain complex, adaptation outcomes are mediated by various internal and external political, social and economic factors (Bisaro et al., 2010). Whether adaptation is considered successful or not also appears to depend on the perspective of major actors involved (individuals, households, communities, their institutions and state and non-state partners) on objectives set and how they define climate change both as a problem and context (Eriksen et al., 2011).

While adaptation intends to achieve positive expected outcomes, it may result in unintended negative impacts. According to Davies and Bennett (2007), some adaptations have had negative impacts on food security and rural economies. Such cases of maladaptation only deplete assets, impose negative externalities and eventually increase vulnerability. Even accounting for good adaptation practices, the impact of climate change can be extremely high (Gebrehiwot and Veen, 2013; Tsegaye et al., 2013). Developing countries, often with marginal production systems, have less capacity to adapt (Esham and Garforth, 2013), forcing them to focus on short-term measures that undermine long-term adaptation. The adaptive capacity of the agriculture sector in many regions of Africa is severely limited by persistent and widespread poverty (Davies and Bennett, 2007; Bryan et al., 2013).

1.4 Smallholder farming systems in southern Ethiopia and climate change adaptation

The drylands of East Africa which include Southern Ethiopia pastoral and agropastoral systems are inhabited by populations that are far more vulnerable and poorer than their counterparts in higher rainfall areas (Galvin, 2001; Luseno et al., 2003). These areas are home to hundreds of thousands of pastoral and agropastoral communities that depend on traditional livestock keeping as a major source of income, food and livelihood (Desta and Coppock, 2004). Persistent and recurring droughts and changing climatic patterns in the region have taken a toll on this region's pastoralists, and has led to increased poverty, limited livelihood options and increased vulnerability to climate change (Luseno et al., 2003; Tache and Oba, 2010). In particular, rampant food insecurity and abject poverty which contributed to their vulnerability are often linked to the negative impacts of climatic change.

No adaptation is not a viable option. Optimal adaptation will be required to overcome the potential impacts of climate change on food production, farm income and agricultural biodiversity in such a climate change vulnerable system (Challinor et al., 2007; Reidsma, 2007). The adoption of proactive climate change adaptation strategies for smallholder farmers has not been paid sufficient attention while the historical reaction to climate-induced stresses such as droughts and floods has been in disaster response mode (Conway and Schipper, 2011). Pathways for successful adaptation should be facilitated through well-informed decision-making that considers three key features of the dryland pastoral and agropastoral systems in southern Ethiopia.

- *Smallholder farms are predominantly rainfed*

Smallholders in southern parts of Ethiopia rely on rainfed production and only 5% of the cultivated land is under irrigation (Seleshi and Zanke, 2004). Previous studies have shown that even minor fluctuations in climatic patterns can have significant impacts on the productivity of smallholder farming systems (Birhanu and Geert, 2013). Understanding the overwhelming reliance on the natural climate for agricultural production and the critical need for adaptation is key to successful adaptation in these subsistence and traditional smallholder farming systems.

- *Smallholder farms are dynamic and heterogeneous*

Smallholder farming systems in Ethiopia are facing rapid biophysical, socioeconomic and political changes. In addition, smallholder farming systems across Ethiopia are culturally

diverse and face different biophysical conditions (there are 18 major agroecological zones and 49 subdivisions based on variations in temperature, rainfall and the length of the growing season (MoARD, 2005). When developing adaptation policies and strategies, it is important to consider both the dynamic nature of the smallholder farming systems and the wide range in the vulnerability of these systems (O'Brien et al., 2007; Soares et al., 2012).

- *Smallholder farms are traditional and poorly resourced*

Smallholder farms in Ethiopia practice traditional archaic agricultural techniques (Di Falco et al., 2011). To date, there has been a little uptake of improved modern and climate-smart management practices and technologies to enhance agricultural productivity and climate resilience. There is a limited understanding of how to shift from traditional and subsistence farming into modern agriculture, and agricultural production is generally poorly market-oriented (Gebremedhin et al., 2009; Shiferaw et al., 2011). Often the goal with the subsistence farming is to achieve short-term food security and farm income goals rather than long-term economic prosperity which translates into weak adaptive capacity. Poor financial resources constrain the utilization of external inputs that smallholders can access and present a key barrier to the adoption of appropriate climate change adaptation strategies.

Particularly in Borana lowland systems, pastoralism with extensive and resource extractive rainfed production system remains by far the most important means of livelihood and natural resources management becomes vital with implications for adaptation. The management system allows overcoming seasonal shortage of pasture and climate-induced vulnerability. The Borana rangeland management system involves seasonal allocation of communal grazing lands which dictates mobility of herds between wet and dry season grazing areas to deal with vulnerability feed shortage. For purposes of natural resource management, the Borana household herd is split into two groups - home based *warra* and satellite *forra* herds (Desta and Coppock, 2004; Solomon et al., 2007). The home-based divide includes lactating cows and weak animals while satellite herds constitute animals which can move to distant wet-season grazing areas in fall-back regions far from encampments. Through herd mobility managed by traditional resource governing institutions, the management system strives to minimize grazing pressure and ensure the year-round co-existence of water and pasture to support extensive livestock production. Competition for communal grazing land is not unusual among mobile herds and social groups particularly during drought periods when vulnerability is at its high. While the rangeland management system in Borana superficially claims a “grazing commons”, in practical terms it does so more at a *madda* level which is a

local grazing land management unit (Coppock, 1994). The *madda* is often associated with well groups which envisage integrated management of range and water resources. In the face of increasing population pressure and resource degradation, the Borana pastoralists are facing the challenge of ensuring sustainable use of natural resources.

While pastoralism is a much preferred way of traditional life in Borana, households are increasingly involved in non-pastoral livelihoods such as cultivation and off-farm employment. Mainly since the late 1980s, parcels of land were increasingly annexed from common access grazing areas by both influential individual Boran and local communities not only for cultivation but also for private forage reserves (Coppock, 1994; Desta and Coppock, 2004). Particularly after the 1983-4 drought, more land was put under cultivation as households opportunistically started to plant food crops such as maize and cowpea to fill the food security gap, particularly due to the high rate of cattle mortality. Tache and Oba (2010) indicated that poverty (mainly decline in livestock asset) alone is not the only driving factor for herders to engage in cultivation of crops. While different household wealth groups are motivated by different criteria and involving mechanisms remain complex, contributing factors such as changes in land use policy, increasingly unreliable rainfall and shortage of labour were suggested to be looked at. As a result, cultivation of crops led to fragmentation of grazing lands creating isolated ecosystems and creates conflicts by expanding into key communal grazing landscapes eventually depleting dry season grazing reserves thereby limiting options for adaptation (Boru et al., 2014) and contributing to a decline in livestock holding (Tolera and Abebe, 2007). Nonetheless, there is little evidence that cultivation of these small and fragmented plots enabled food self-sufficiency among the Borana (Thornton et al., 2007; Tache and Oba, 2010). As cultivation brings competing demands for land with livestock production, it still remains a less favoured farming practice by the traditional land tenure system.

Given their high degree of vulnerability, Ethiopian smallholders in general and Borana pastoral and agropastoral communities have been making efforts to adapt to climate change and overcome its adverse effects but have not necessarily been successful (Davies and Bennett, 2007; Bryan et al., 2009). Addressing the problem of unsuccessful adaptation and identifying potential action points however requires a sound understanding of the adaptation process and underlying barriers (Bryan et al., 2009; Nielsen and Reenberg, 2010) and interest in how to best measure the successfulness of adaptation programs has emerged (Stadelmann et al., 2011). There are however issues with measuring the accuracy and effectiveness of adaptation and there are no universally agreed upon metrics (Davies and Bennett, 2007; Doria

et al., 2009). To date, only a few studies have employed systematic approaches to studying the effectiveness of local adaptation in a range of traditional farming systems including those in Ethiopia. There are significant knowledge gaps in understanding the agricultural adaptation processes in southern Ethiopia, the motivations that drive farmers to adapt and the barriers to adaptation which limit the adaptive capacity of traditional farming systems.

1.5 Smallholder perception and climate change adaptation

There has been an increasing level of awareness about climate change and its impacts on agriculture by smallholders and their communities in developing countries (Semenza et al., 2008). However, it is doubtful whether smallholders and rural communities are able to track and understand the actual climate change due to their limited access to reliable climate information (Maddison, 2007). The fact that climate change is a complex process which involves natural variability of local climate makes it difficult for a person to discern long-term climate change. Nor can they be expected to know what constitutes the best response to climate change given that the options may be outside their range of experience (Maddison, 2007). While various factors affect, attitudes towards climate change and risk, affect adaptation behaviour (Patt and Schröter, 2008). Perception of climate change has been suggested to drive the precise nature of adaptive behaviour that shapes adaptation routes, processes and outcomes (Patt and Schröter, 2008; Pauw, 2013). As climate changes smallholders are most likely experiencing a transitional period of losses to their livelihoods due to inappropriate perception and inaccurate responses.

Accurate and informed understanding of the views of agricultural communities towards climate change, and the need for adaptation is of critical importance. Policy makers must consider the perspective of intended beneficiaries to acquire their willing cooperation (Patt and Schröter, 2008). Previous efforts to support the development needs of Ethiopian rural communities and promote the adoption of climate change adaptation strategies have not considered, as a context for action, local views about climate change (Homann, 2004; Lavers, 2012). Recent history has shown that there is a significant divergence of ideas about adaptation and development approaches between local communities, and between state and non-state actors which has seriously affected processes and outcomes (Homann et al., 2008a). Understanding how smallholder farmers perceive climate change in terms of local climate attributes and determining those factors which influence this perception are critical to the design and success of climate change adaptation and development initiatives.

1.6 The role of rural institutions in climate change adaptation

Adaptation to climate change in agriculture involves a wide range of actors including individuals, households, communities, state, non-state and local institutions (Adger et al., 2005). Local institutions play a pivotal role in shaping adaptation processes and outcomes through providing the local context for interventions and prescribing routes for adaptation. They play an especially important role in adaptation where collective decision-making and shared lifestyles underpin a society (Agrawal and Perrin, 2009). Despite this role, local institutions are not always effectively engaged with or integrated into decision-making by formal institutions in adaptation and development (Watson, 2003; Homann et al., 2008a) which partly is attributed to negative relationships between them. As a result, competition may compromise synergy and lead to negative outcomes.

Indigenous institutions played a pivotal role in supporting pastoralism through enabling communities to act in favour of their collective interest. However, there have been state interventions in a bid to force rural communities shift from traditional pastoralism to 'modern agriculture'. Government policies (based on top-down development approaches) in response to the rising demand to increase and modernize food production has meant the indiscriminate displacement of pastoralism (Dong et al., 2011) that undermine indigenous institutions. Agricultural intensification is being imposed and implemented in a way that negatively affects the adaptive capacity of a traditional system of collective resource management (Homann et al., 2008a; Tsegaye et al., 2010). As a result, indigenous institutions such those involving resource governance were undermined, and vulnerability to climate change has been exacerbated by pastoralists worldwide being forced to shift their way of life into more marginal areas (Dong et al., 2011).

1.7 Objectives of the thesis research

The overarching objective of this thesis was to gain insights and enhance our understanding on how to improve climate change adaptation policies and interventions for traditional smallholder farming communities in Ethiopia. The study focussed on the Borana pastoralist and agropastoralist communities of southern Ethiopia which depend on rainfed extensive production systems. These communities are highly vulnerable to climate change and recurrent droughts have negatively impacted food production, farm income and rural livelihoods. The study employed a mixed-method approach of qualitative and quantitative studies that allows

methodological pluralism or eclectism that often results in superior research as compared to the traditional purist or mono-method research approach.

The following interrelated research questions (see Figure 1) crucial to the development of successful climate change adaptation policies in agriculture sector were explored:

1. How do smallholders perceive climate change and its associated impact on local agriculture and livelihoods?
2. In what ways do smallholders and their communities respond to adapt to climate change, and what barriers impede successful adaptation?
3. What roles do rural indigenous institutions play in supporting agricultural adaptation to climate change?

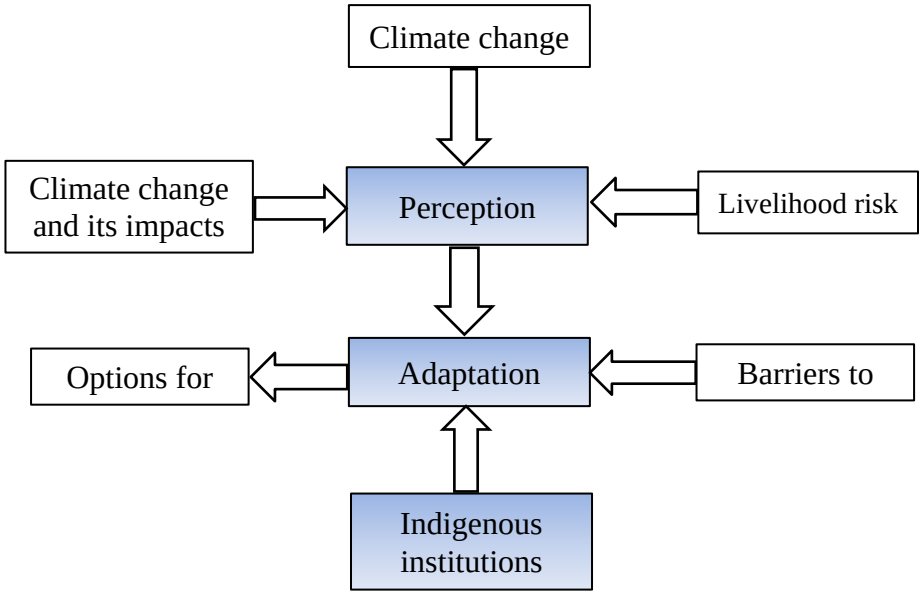

Figure 1. Summary of approach taken to investigate relationships between perception, adaptation and indigenous institutions in this study

Study setting

The study was conducted in Borana pastoral and agropastoral systems in south Ethiopia. We deliberately selected the Borana pastoral and agropastoral systems because they represent one of the most vulnerable agricultural systems to climate change in Ethiopia. In addition, agricultural exports from the area in the form of livestock contribute significantly to national foreign exchange earnings and Ethiopia's agricultural economy. These farming systems are subject to rapid socioeconomic, biophysical and policy changes due to both internal and external pressures smallholders in the area grapple to adjust to.

The study area is located in the Borana administrative zone of Oromiya Regional State, south Ethiopia. The Borana zone is broadly divided into two agroecological zones - the high-altitude humid lands to the north, and semi-arid lowlands to the south. The latter represents the heartland of the pastoral and agropastoral systems of the Borana Plateau (Tache and Irwin, 2003). The seven districts of the study area (Yabelo, Dire, Moyale, Miyo, Arero, Teltele and Dugda Dawa) constitute 54% (587,749 heads) of the human population, and 91% (41,177 sq km) of the total land mass of the Borana administrative zone (CSA, 2011) and the heartland of Borana pastoral and agropastoral systems.

The study area has four main seasons based on its rainfall variation and agricultural production depends on how favourable seasonal conditions are. These are namely *Bona* (long dry spell from December to February), *Gana* (long rainy period from March to May), *Adolessa* (short dry spell from June to August) and *Hagaya* (short rainy period from September to November). With this bimodal pattern the area receives a mean annual rainfall ranging from 350 mm around Wachile town (Arero district) to about 1,100 mm in Moyale town (Moyale district) on the border with Kenya, with an overall average of about 700 mm (Coppock, 1994). Interannual and interseasonal rainfall variability is consistently high across locations ranging between 18 and 69 percent of the annual mean (Angassa and Oba, 2007). The area on average receives 86 rainy days throughout the year. The dependence of agricultural production on natural climate in the area highlights the significance of vulnerability of local agriculture and livelihoods to minor changes in climate.

Farms and farming systems in Borana are complex and heterogeneous characterized by livestock dominated rainfed farming systems. Traditional and subsistence extensive livestock production with transhumant pastoralism (Watson, 2003; Hurst et al., 2012) is the pillar of the regional economy and main source of livelihood. The production system is rapidly changing mainly due to climate-induced pressures in local ecosystems the view local communities too share (Coppock et al., 2008) and diversification seems an increasingly common phenomenon (Eneyew, 2012). The Borana zone has 1.6 million cattle, 1.2 million small ruminants, 0.16 million equines, 0.11 million camels and 0.2 million poultry (CSA, 2011).

The Borana are by far the largest ethnic group inhabiting the area while Somali, Gebra, Garri and Konso ethnic groups constitute relatively small proportions. The Borana community, encompass kinship groups of 2 moieties and 17 clans (Tache, 2008) which underpin their strong social networks and traditional institutional structure. Extensive livestock farming is a culturally favoured ‘way of life’ and there are doubts whether the traditional agriculture is a viable business enterprise. Collective resource governance and wide social networks are

important attributes of the community and customary institutions play pivotal role in determining power structures and relationships among members of the society. The *Gadda* system, a complex and overarching egalitarian system of the Borana, is one of the most resilient institutions despite the recurrent droughts, loss of grazing and water, and oppressive interventions by successive governments in the country (Bassi, 2005). The author argues that this complex, transboundary and still flourishing institution enjoys tremendous trust and support by the Borana communities residing on both sides of the Ethiopian-Kenyan border.

1.8 Outline of the thesis

This thesis is organized as follows. Chapter 2 reviews the literature relevant to the perception of climate change, agricultural adaptation to climate change and role of indigenous institutions in facilitating adaptation. Drawing on existing literature, major knowledge gaps in understanding perception, adaptation responses and role of indigenous institutions are identified.

In chapter 3, smallholder (farm householder) perception of climate change and its impact on local agriculture are analysed using empirical data from a farm household survey. A chi-square test was carried out to test whether farm households perceived climate change across different climatic variables of agricultural significance in their area. In addition, the effect of different farm and household characteristics on perception levels was investigated using psychometric model approach. Multinomial logistic analysis was employed to analyse relationships between outcome (perception levels) and explanatory variables (various farm and household attributes). Perception levels of climate change strongly influence and lead to adaptation decisions and choice of options which are further explored in chapter 4.

In chapter 4, adopted agricultural adaptation options and barriers to successful adaptation are examined using a pressure-state-response theoretical framework. The analysis considers climate change adaptation as one form of human-environment interactions in which rural smallholders respond to current or anticipated climatic pressures to overcome any negative effects on agricultural yield and farm income. As the analysis of options and barriers indicated that institutions play an important role in prescribing some adaptation options, the subsequent chapter explores the role of indigenous institutions in facilitating local adaptation to climate change.

In chapter 5, the role of indigenous institutions in climate change adaptation at the local level is examined. Key roles of indigenous institutions are identified and analysed using the adaptation, institutions and livelihood framework. As part of these studies, empirical data

were collected using key informant interviews from local elders and members of the institutional leadership.

In chapter 6, the results from all chapters are discussed and major findings of this study highlighted. Recommendations on how to improve future adaptation in smallholder agricultural systems and how to integrate these adaptations into future development programs are suggested. The chapter concludes by outlining future priority research directions and opportunities for advancing adaptation in smallholder agriculture in Ethiopia and developing countries.

Chapter 2: Literature review

2.1 Introduction

2.1.1 Ethiopia and its smallholder agriculture

Agriculture in Ethiopia is the backbone of the economy, vital for its long-term economic development and is seen as a powerhouse in the nations' effort to achieve food security, poverty reduction and rural development (Deressa et al., 2010; Gebre-Selassie and Bekele, 2011). Despite the country's rapid economic growth in the past decade, food insecurity still remains a wide-spread problem and poverty is more severe and pervasive in rural areas than in urban areas. Recent estimates indicate that the predominantly rainfed agriculture sector contributes 45% of the national gross domestic product and 85% of total export earnings (Arndt et al., 2011; Tilahun et al., 2011; Admassie and Abebaw, 2014). The sector provides employment for 80% of the population and contributes 70% of the country's industrial raw material (McIntosh et al., 2013). In terms of total agricultural value, crop production contributes about 60% to this value while livestock and other sub-sectors including forestry contribute around 27 and 13%, respectively (McIntosh et al., 2013). Crop production by area is mainly cereals (84.5%) followed by pulses (11.1%) and others (4.3%). Five crops account for almost all cereal production: maize (15.8%), teff (*Eragrostis tef*) (25.8%), barley (12.3%), sorghum (12.4%) and wheat (10.8%) (FAO, 2006). Though food crops predominate crop agriculture, cash crops such as coffee and khat also contribute significantly to agricultural output.

The agriculture sector is predominantly characterized by subsistence and rain-fed mixed crop-livestock systems of small-scale farming using traditional technologies. In Ethiopia, 'smallholder farmers' are often defined as farmers who manage farms that are usually no bigger than 2 ha in size, relying on household labour for production and sell part of their produce for cash (Akram-Lodhi and Kay, 2009). Farms <1 ha comprise more than 26% of the agricultural land; almost 60% is in holdings of less than 2 ha and the rest in holdings between 2-2.5 ha (FAO, 2006). Although large-scale farming is gradually expanding, low-external-input small-scale farms cover about 95% of the total land area under cultivation and 90% of the country's total agricultural output (Arndt et al., 2011; McIntosh et al., 2013). Despite abundant water resources and huge potential for irrigated agriculture, only 13% of the potentially irrigable land is under irrigation (Arndt et al., 2011) while the total irrigated land accounts for only 5% of the total land under cultivation (Awulachew and Ayana, 2011). The small-scale agriculture largely relies on highly variable rainfall distributions and remains

vulnerable to the vagaries of seasonal climate. In fact, 65-75% of the total land mass and 46% of the total arable land is classified as dryland in Ethiopia (EPA, 1998; Yonas, 2001).

The fact that majority of Ethiopians depend on agriculture for their livelihood suggests a vital link between climate and development. Specifically, the performance of the Ethiopian agriculture-led economy is closely linked to climate due to its overwhelming dependence of agricultural production on natural climate (Conway and Schipper, 2011). Climate change induced abnormalities such as droughts, floods, rainfall failure and heat waves have had devastating effects on agricultural production and consequently on food insecurity, farm income and livelihoods in Ethiopia (Ferede et al., 2013). Thus addressing climate change induced vulnerability through robust adaptation is of critical importance. Given the importance of agriculture to the national economy and its socio-cultural value, the Ethiopian government has instituted an agricultural development-led industrialization policy of structural change and long-term development. This policy made smallholder agriculture at the center of the development agenda, and pillar of the industrialization policy and long-term development strategy (FDRE, 2011; Lavers, 2012). Moreover, it aimed to transform the structure of the economy and address food security, agricultural productivity and rural development challenges to achieve rapid economic growth, alleviate rural poverty and improve the rural livelihoods of millions of smallholder farmers (Bacha et al., 2011).

The vulnerability of Ethiopian agriculture to climate change is tremendous. In view of its dependence on natural climate, the sector is identified to be one of the most vulnerable economic sectors (MoA, 2011). Studies indicate that under a ‘‘no adaptation scenario’’ the country’s GDP will be 10% lower than the counterfactual no climate change (historical climate) baseline by 2050 (Robinson et al., 2012). In response to this vulnerability, the national government launched the Climate-Resilient Green Economy initiative in 2011 to enhance the resilience of the national economy to current and anticipated climate change (FDRE, 2011). This plan promotes the alignment of social, economic and environmental development goals to ensure a long-term and sustainable future in agriculture.

2.1.2 Climate systems - Climatic and agroecological zones

Ethiopia is located in the northern tropical zone and its climates are largely controlled by the seasonal migration of the Inter-tropical Convergence Zone and related atmospheric circulations (NMSA, 2001; Riddle and Cook, 2008). The extensive altitudinal range and complex topography of Ethiopia have resulted in topography-induced climatic variation resulting in diverse microclimates ranging from cool highlands in the inner north to hot desert

microclimates in the southeast (NMSA, 2001; Seleshi and Zanke, 2004). The diverse climate systems and agroecological zones provide scope for a wide range of agricultural land-uses and livelihood choices for rural communities (Ferede et al., 2013).

Ethiopia is endowed with a diverse climate that can be classified based on different approaches and criterion. There are different approaches to climate classification: according to rainfall regimes: Thornthwaite's climate classification (Thornthwaite, 1948); Köppen's climate system (Köppen, 1918); agroecological zonation (Yohannes, 2003; Tesemma et al., 2010) and local or traditional classification systems (MoARD, 2005). Among these, the two latter approaches have been commonly used to classify the climate systems of Ethiopia.

The traditional classification system is based on altitudinal and thermal variations. It divides the country into five major climatic zones (Table 1) namely - Wurch (extreme highlands 3,200 - 3,700 m), Dega (highlands 2,300 - 3,200 m), Weyna-dega (midlands 1,500 - 2,300 m), Kola (lowlands 500 - 1,500 m) and Bereha (hot lowlands <500 m) (MoARD, 2005; Deressa, 2010). The classification mainly demonstrates altitude-driven variations in rainfall and temperature conditions. Weyna-dega (midlands) is the dominant agricultural belt suitable for rainfed farming in the country and most of the major crops including food (tef and maize) and cash crops (tea and coffee) are grown in this zone (Hurni, 1998).

Table 1. Altitude driven traditional climatic zones and their salient physical characteristics in Ethiopia

Zone	Altitude (meters above sea level)	Average annual rainfall (mm/year)	Average annual temperature (^{o}C)
Wurch (Alpine)	above 3,200	1,200 - 2,200	below 11.5
Dega (Highlands)	2,300 - 3,200	900 - 1,200	11.5 - 16.0
Weyna-dega (Midlands)	1,500 - 2,300	800 - 1,200	16.0 - 20.0
Kola (Lowlands)	500 - 1,500	200 - 800	20.0 - 27.5
Bereha (Desert)	below 500	below 200	above 27.5

By contrast, the agroecological zonation system combines ecological concepts and agricultural potential which signifies the potential and limitations for agricultural production (Chamberlin and Schmidt, 2011). Based on macro-level climate information, it categorizes the country's climate into 32 major agroecological zones and 49 subdivisions based on combined moisture, temperature regimes and soil condition (MoARD, 2005) (Fig. 2). Specifically, the agroecological zonation system, based on length of growing season (i.e.

moisture regime), groups the climate into seven broad categories of varying size: arid (30.9% percent, 35.1 million ha); semi-arid (3.3%, 3.8 million ha); sub-moist (16.6%, 18.8 million ha); moist (25.6%, 29.0 million ha); sub-humid (16.0%, 18.2 million ha); humid (6.0%, 6.8 million ha) and per-humid (0.8%, 0.9 million ha) (MoARD, 2005). Across these agroecological zones, there are large spatial and temporal variations in temperature and rainfall presenting distinct social, economic and environmental features, which have implications for agricultural development and adaptation to climate change. Regardless of the climate classification used to describe Ethiopia's climate system, significant variations in climate and associated patterns of change clearly present distinct adaptation potentials and challenges to the country (Fig. 2).

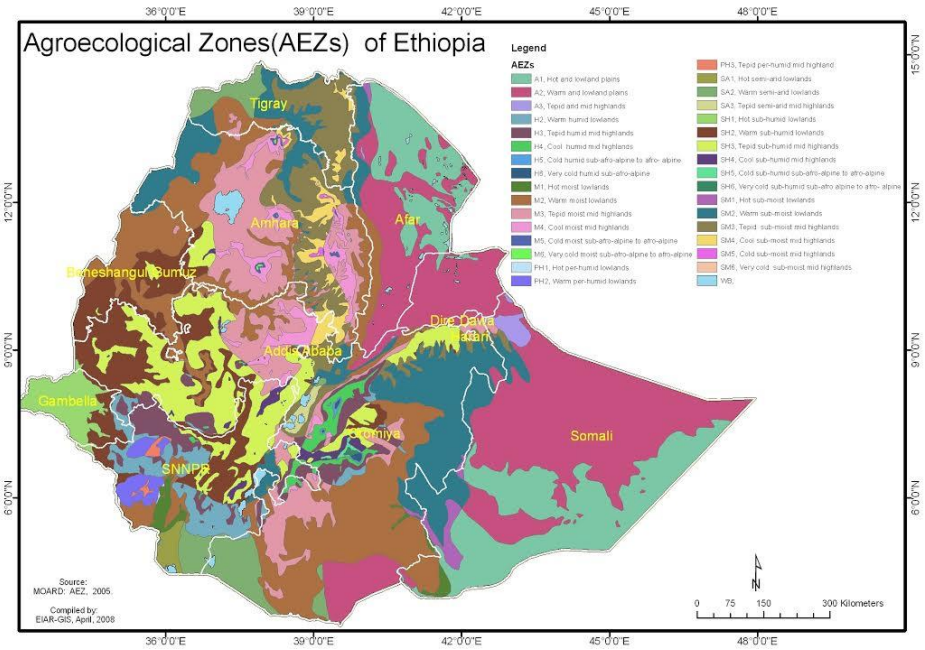

Figure 2. Major agroecological zones of Ethiopia (Source: Gorfu and Ahmed (2011))

2.2 Vulnerability of Ethiopian agriculture to climate change

2.2.1 Theories and concepts of vulnerability

Although the term vulnerability is a common discussion point across a wide spectrum of traditional disciplines, it has a broad and often contested range of definitions spanning knowledge domains from psychology and engineering to economics, geography and anthropology (Eakin and Luers, 2006; Fussel, 2007b; Soares et al., 2012). The complex and dynamic nature of vulnerability, which has wide implication for adaptation, is however a

common denominator for definitions from the wide range of disciplinary traditions (Leichenko and O'Brien, 2002; Eakin and Luers, 2006).

Vulnerability can encompass a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (Fussel, 2007b). Vulnerability can also mean susceptibility to harm or damage from exposure to direct or indirect stresses associated with environmental and social changes in the absence of the capacity required to adapt (Adger, 2006; Soares et al., 2012). In climate change science, vulnerability is defined as the propensity or predisposition to be adversely affected (IPCC, 2014), and is described in relation to key environmental change and encompassing biophysical and socioeconomic components of vulnerability. Similarly, Turner et al. (2003) define vulnerability as the degree to which a system is likely to experience harm or get wounded due to exposure to a hazard. From a human systems point of view, vulnerability can be defined as ability of individuals or social groups to respond to, to cope with, recover from or adapt to, any external stress placed on their livelihoods and well-being (Kelly and Adger, 2000). In this study, we therefore will employ this definition of vulnerability to environmental stress (climate variability and change) and emphasize the concept of vulnerability that puts the social and economic well-being of a society at its center.

Approaches to vulnerability assessment

There have been many efforts to define, classify and understand the meaning and use of the term vulnerability (Adger, 2006; Fussel, 2007b; O'Brien et al., 2007). O'Brien et al. (2007) categorizes vulnerability as ‘outcome’ and ‘contextual’. Outcome vulnerability is linked to a scientific framing and the approach stipulates that outcome vulnerability is a linear result of the projected impacts of climate change on a particular exposure unit. Contextual vulnerability is linked to a human-security framing; both climate variability and change are considered to occur in the context of political, institutional, economic and social structures and changes, which interact dynamically with contextual conditions associated with a particular ‘exposure unit’. The two types of vulnerability are more than two different interpretations but are two different discourses and framings of the climate change problem with practical implication for climate change policy and responses. In general, there is an increasing recognition of the importance of approaching vulnerability from an explicitly defined perspective (Dong et al., 2011) in order to define and frame climate change problems.

Measuring vulnerability involves a complex task of building qualitative and quantitative assessments using a significant range of explanatory parameters (Adger, 2006; Harley et al.,

2008). Due to its complexity, achieving temporally and spatially comparable robust metrics to measure vulnerability however remains a major challenge in vulnerability research (Adger, 2006; Kelly and Eriksen, 2007; Cannon and Müller-Mahn, 2010). The metrics must reflect biophysical and social processes that are often in a continuous state of flux and often difficult to capture (O'Brien et al., 2007). For instance, in their study to examine vulnerability of social-ecological systems in an agricultural region of Mexico, Luers et al. (2003) developed a general metrics to assess vulnerability. The authors expressed vulnerability in its simplified form as a function of sensitivity to stress, state relative to threshold and probability of exposure to stress, and tried to assess relations between stressors and outcome variables. The outcome or variable of concern could be any legitimate potential measure such as farm household incomes which respond to specific stressor in a given farming system. However, the authors still acknowledge the difficulty to capture those various external factors that affect the outcome variable.

$$\text{Vulnerability} = \frac{\text{Sensitivity to stress}}{\text{State relative to threshold x Probability of exposure to stress}}$$

The metrics for vulnerability must reflect biophysical and social processes that are often in a continuous state of flux and often difficult to capture (O'Brien et al., 2007). This denotes the dynamic nature of vulnerability which is critical for adaptation. Due to its complexity, however, achieving temporally and spatially comparable robust metrics to measure vulnerability remains a major challenge in vulnerability research (Adger, 2006; Kelly and Eriksen, 2007; Cannon and Müller-Mahn, 2010). Future vulnerability research should address this aspect which is very critical for adaptation planning.

Vulnerability context of Ethiopian economy and its agriculture

The agricultural sector of Ethiopia is considered one of the country's most vulnerable economic sectors to the impacts of climate change and its extremes (Deressa, 2010; Conway and Schipper, 2011; MoA, 2011). This vulnerability has significant implications for the well-being of individuals and communities whose livelihoods depend on the agricultural sector. The degree of vulnerability differs across Ethiopia's diverse agroecological zones and associated farming systems. For example, dryland systems are more vulnerable due to inherently low rainfall and high climate variability, and limited opportunities for livelihood diversification. Vulnerability to climate change in Ethiopian agriculture thus can be explained

in terms of three elements: 1) exposure to climate perturbations, 2) sensitivity of the agriculture sector to stresses, and 3) weak adaptive capacity of farming communities (Fig. 3).

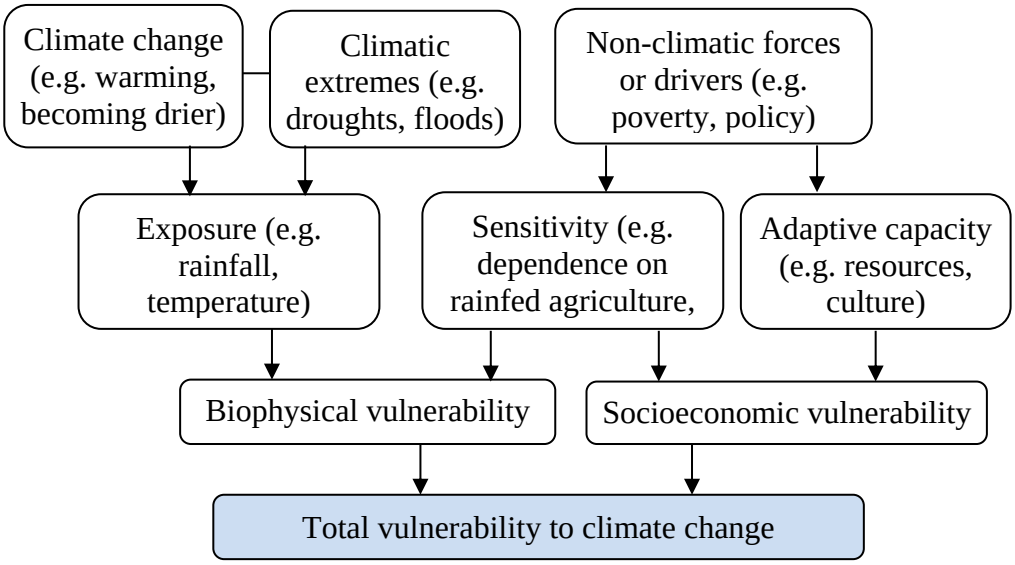

Figure 3. Conceptual model for the assessment of vulnerability in Ethiopian agriculture (adapted from Fussel and Klein (2006))

Exposure

Climate change vulnerability is commonly broken down into three components: exposure, sensitivity and adaptive capacity (Challinor et al., 2007; Soares et al., 2012). These components help to assess the nature of vulnerability and are useful tools for explaining vulnerability as a precedent to adaptation. Exposure is defined as the degree of climate stress upon a particular unit analysis; it may be represented as either long-term changes in climate conditions, or by changes in climate variability, including the magnitude and frequency of extreme events (IPCC, 2012; Soares et al., 2012). By this definition, Ethiopia is one of the most exposed countries in the world to climate change having already experienced significant climate change in the past which is expected to continue. A study by Seleshi and Zanke (2004) revealed largely negative rainfall anomalies with the values of the main rainy season (June to September) during the second half of the 20th century frequently below the long-term average. Exposure to increasing inter-annual and seasonal variations in rainfall, particularly in dryland areas inhabited by pastoral and agropastoral communities will pose considerable challenges for agricultural production in rainfed systems.

Sensitivity

Sensitivity can be defined as the degree to which a system is being affected by climate change whether that be in a positive or negative manner with the effect being direct (e.g. change in crop yield) or indirect (e.g. damages caused by coastal flooding) (IPCC, 2014). The fact that the Ethiopian economy predominantly relies on rainfed agriculture sector (95%) makes it especially sensitive to climate perturbations (Awulachew and Ayana, 2011). Approximately 97% of the national food production comes from rainfed agriculture suggesting an excessive reliance on rainfed production for food security and farm income for majority of Ethiopians (Bacha et al., 2011).

The nature and strength of the relationship between economic growth and climatic conditions was demonstrated by the World Bank (2006). The study found strong relationship between rainfall trends in Ethiopia and the GDP of the country's agriculture-based economy (Fig. 4). Other studies have also shown a strong relationship between rainfall variability and the performance of the national economy including food production between 1980s and 2000s (Araya and Stroosnijder, 2011; Conway and Schipper, 2011). The findings presented in figure 4 suggest that, good rains result in above average production, and vice-versa while other non-climatic factors remain constant.

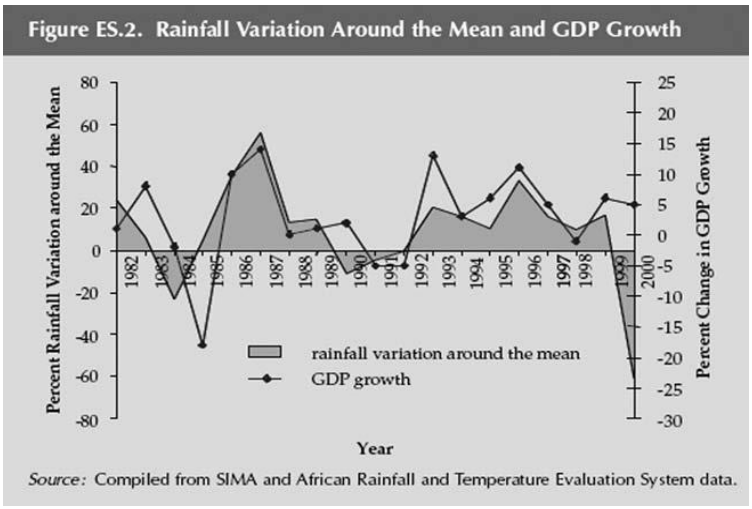

Figure 4. Rainfall variability around the mean and fluctuations in GDP growth for Ethiopia (World Bank, 2006)

Adaptive capacity

Adaptive capacity is the ability of a system (human or ecological) to adapt; to moderate potential damages, to cope with the consequences or take advantages of opportunities (Soares

et al., 2012). Natural, human, civic and economic resources, and level of agricultural innovation are important components in generating the adaptive capacity index in the agricultural sector (Iglesias et al., 2011; Upton, 2012). A study by Haddad (2005) suggested that Ethiopia is ranked in the lowest quantile for adaptive capacity in agriculture to climate change when compared to other nations. Approximately 90% of Ethiopia's agriculture is under subsistence small-scale farms using traditional technologies. Weak adaptive capacity can be partly attributed to this subsistence nature constrained by poverty as well as weak institutional support (Davies and Bennett, 2007; Conway and Schipper, 2011; Upton, 2012). Capital-intensive medium and large scale farms constitute an insignificant proportion of the farming sector and are often the result of foreign investment (Lavers, 2012). Reports indicate that for 55% of rural households, annual crop production would feed them for up to 6 months at which point these households become food insecure (Tilahun et al., 2011). This information reflects the limited financial capacity of farmers and their limited access to those external inputs required to withstand the impacts of climate change and enhance productivity.

Various natural, socioeconomic, cultural and institutional factors contribute to the weak adaptive capacity of smallholder farmers in Ethiopia (Bryan et al., 2013). Indeed, the weak adaptive capacity is closely interrelated with the level of economic growth and generic development factors including income, education and health (OECD, 2014). Though Ethiopia is among the five fastest growing economies in the world, it still remains one of the least developed countries (Di Falco et al., 2012). Ethiopian smallholders' weak adaptive capacity is further exacerbated by its weak institutional capacity which is unable to provide adequate support to farmers in their effort to adapt particularly in marginalized farming communities such as pastoral societies in dryland systems including the study area (Muller-Mahn et al., 2010; Upton, 2012; Tsegaye et al., 2013).

2.3 Perception of climate change and implications for adaptation

2.3.1 Theoretical approaches to study perception

Public opinion and perception can compel or constrain climate change policy (Sjöberg, 2000a; Maddison, 2007; Deressa et al., 2011; Pauw, 2013). Perception of climate change and its associated impact are therefore important determinants of responses to climate change. The psychological perspectives to climate change especially its perception has gained increasing attention from research, policy and practice (Roco et al., 2014). Psychometric and cultural theory are key approaches used to explain risk perceptions (Ng and Rayner, 2010). Both approaches have their critics (Sjöberg, 2000a; Ng and Rayner, 2010; Akerlof et al., 2013).

The psychometric theory approach emphasizes cognition and heuristics that affect human attitude and perception of climate change. It suggests that different socio-economic, demographic and institutional factors affect perception. It hypothesizes that perception is objectively quantifiable and predictable, and assumes humans use their analytical and experiential powers to evaluate information, make judgement, form attitudes, beliefs and perceptions (Grothmann and Reusswig, 2006; Leiserowitz, 2006). This approach conceptualizes perception as a function of various social, economic, political, environmental and other attributes that shape behaviour and psychology of individuals and social groups.

The second approach to study perception of climate change is based on cultural theory and recognises an individual's tendency to base their perceptions on factual beliefs that reflect their intrinsic social value and way of life (Adger et al., 2009; Kahan et al., 2010). The cultural theory states that system changes are viewed through either individual or societal lenses, and that belief and perception is culturally constructed (Akerlof et al., 2013). The cultural theory assumes that cultural beliefs are the normative beliefs of a group or community suggesting that socio-cultural factors have important value in shaping attitudes (Weller, 2007; Kahan et al., 2010; Teka and Vogt, 2010; Crona et al., 2013). A good example of a cultural theory model is cultural-consensus-analysis (CCA) used to study perception related to climate change (Leiserowitz, 2006). It conceptualizes culture as cognitive and assumes consensus as an 'underlying truth' leading to beliefs and agreement.

2.3.2 Role of perception in adaptation to climate change

Understanding the perception of individuals, social groups or communities is fundamental in promoting climate change responses as it defines the local socio-political contexts within which practitioners, policy makers and researchers operate. Perception of climate change helps to define a context for future action. It is widely agreed that the public needs to recognize climate change as an issue of interest, appreciate its significance and consequences (Smit et al., 2000; Patt and Schröter, 2008; Adger et al., 2009; Hansen et al., 2012). Ratter et al. (2012) reported that despite the wealth of scientific evidence about, and media coverage of climate change, there appears to be a decline in general public interest about climate change in certain regions of the world.

Public perception of climate change has greatly shaped public climate policies (e.g. treaties, taxes or subsidies) and individual-level climate action (e.g. voluntary actions) (Leiserowitz, 2006; Semenza et al., 2008). In a case study from Norway, O'Brien et al. (2006) reported that in situations where there is complacency and little or no risk perception associated with

climate change, little if any, adaptive action is undertaken. The results of the study underscore the need to better understand what climate change really means for society and define it as a problem or context for action. In a different case study, farmers and policy makers in Mozambique had different perceptions of climate change and its associated risk which ultimately negatively affected a government resettlement program proposed as an adaptation strategy (Patt et al., 2010). The results suggest that there are often differing views of climate change amongst the public, researchers and governments which has far-reaching implications for decision-making and adaptation outcomes (Patt and Schröter, 2008; Pauw, 2013).

Despite the abundance of available scientific evidence and perceived knowledge of climate change (existence and extent), concern is low in some societies, particularly those that are less reliant on climate for their livelihoods (Brulle et al., 2012; Hansen et al., 2012; Akerlof et al., 2013). This low level of concern can be partly attributed to poor communication and inappropriate information about the nature of the threats posed by climate change provided to decision-makers. Weber (2010) defined three different ways of informing decisions related to climate change response - analysis-based, affect-based and rule-based. The author suggested that responses following perception of climate change cannot be sufficiently informed by analysis-based (analytical) decisions due to the large discounting of uncertain future costs of climate change. Affect-based decision (experiential) is unlikely to motivate significant action as different sections of the public are not equally affected or concerned about climate risk (Weber, 2010; Hansen et al., 2012). Both Weber (2010) and Hansen et al. (2012) agree that rule-based decisions which are founded on moral or social responsibility can overcome the limitations of the other two decision-making approaches and offer the best prospects for meaningful and long-term action on climate change.

2.3.3 Barriers to perception of climate change

The fact that climate change is taking place does not mean that it is understood or recognized by everyone. People have difficulty in accurately detecting and tracking climate change because climate change is a slow and gradual modification of average climatic conditions (Hansen et al., 2012) - especially if reliable climate information is limited (Smit et al., 2000). The substantial day-to-day, season-to-season, and year-to-year variability of local weather and climate makes it difficult to discern climate change (Weber, 2010; Hansen et al., 2012; Akerlof et al., 2013). Public opinion of climate change is in large part shaped by personal experiences and cognitive bias from recent local climate variations particularly extremes such as droughts and floods (Leiserowitz, 2006; Pauw, 2013).

Different factors constitute barriers to perception of climate change. Communication of climate change to the public may not necessarily result in increased awareness of climate change. For example, lack of understanding of inappropriately communicated information, poor trust in information sources (e.g. public are suspicious of any exaggeration, bias, etc.) and over communication have contributed to the absence of meaningful perception and engagement of the public in climate change (Lorenzoni et al., 2007; Brulle et al., 2012). Disagreements between scientific and political circles, often exaggerated by the media are another example of a barrier to the awareness of climate change and constrain effective engagement by the public (Carvalho and Burgess, 2005; Lorenzoni et al., 2007). There is evidence to suggest that public opinion is shaped more by political debates than science-based information (Brulle et al., 2012). Meinke et al. (2006) showed that crafting information in socially relevant ways motivates the public and farmers to utilize it and proactively respond to climate-induced risk. The authors argued that science achieves credibility, not just from the technical precision of its content but also by how well the public engagement process is designed and implemented.

Climate change manifests itself at different geographical and temporal scales which has implications for the perception of climate change and sense of its immediacy (Hamilton, 2009; Ruddell et al., 2012). Systematic bias can be found in the way that humans experience and process spatial and temporal information (Ruddell et al., 2012; Akerlof et al., 2013). For instance, farming communities are more likely to discern changes in seasonal climatic conditions than decadal variations as their livelihood is linked to agriculture and where many of the practices follow seasonal cycles (Tambo and Abdoulaye, 2013).

Climate change is not necessarily recognized or perceived in accurate ways, and human assessments and interpretations are not always consistent with evidence from meteorological observations. The inconsistency can be attributed to different reasons including the natural inter-annual variability in the local climate obscures the changes in climate and discerning climate change becomes difficult (Hansen et al., 2012; Akerlof et al., 2013). The day-to-day, season-to-season and year-to-year natural variability of local weather and climate makes it difficult for most people to track and detect long-term changes in climate. Also in reality, climate and non-climate factors interact in complex manner and the effect of climate change is confounded with that of non-climatic factors also called ‘‘intervening conditions’’ such as ongoing soil degradation (Smit et al., 1999; Deressa et al., 2011). Under limited access to climate information which is the case in the study area, identifying the weight factor or

contribution of climate change in agricultural production impact is not easy and may lead to biased judgement.

In addition, 'actual change' is verified by statistical tests of meteorological observations that it remains vague on how such objective statistically verified changes, and subjectively recognized 'perceived changes' can be related and matched. Climate change verified by statistical tests based on 'rational analysis of scientific evidence' may be recognized by one group and not necessarily by others as it depends on individuals' personal experience and socio-cultural characteristics (Weber, 2010). For example, rural communities directly depending on climate sensitive sectors such as agriculture are more sensitive to small changes in climate as compared to the urban-public with livelihoods indirectly linked to the natural climate. In such cases, the urban public may not be in a position to recognize or perceive statistically significant climate change.

2.3.4 Factors affecting farmers' perception of climate change in Africa

Studies on the perception of climate change in Africa have generally taken a psychometric approach (Deressa et al., 2011; Mustapha et al., 2012; Amdu et al., 2013; Belaineh et al., 2013) and only a few a cultural approach (Teka and Vogt, 2010). With a focus on the inherently climate-sensitive rural sector, studies have identified a complex set of farm, household and institutional factors affecting communities' perception of climate change and its associated impact on local agriculture and livelihoods (Semenza et al., 2008; Sampei and Aoyagi-Usui, 2009; Ndambiri et al., 2012; Silvestri et al., 2012) and subsequent decisions to adapt (Maddison, 2007; Hassan and Nhemachena, 2008; Deressa et al., 2009; Gbetibouo et al., 2010; Gandure et al., 2013).

There is clear evidence that education level significantly affects the farmers' perception of climate change among African small-scale farmers and it has been assumed that education increases awareness level and human capacity to process information (Maddison, 2007; Gbetibouo, 2009; Mustapha et al., 2012). In contrast, other studies found no evidence that education level had any significant influence on farmers' views about ongoing local climate change in the highlands of Ethiopia (Deressa et al., 2011) and South Africa (Gbetibouo, 2009). Instead, these studies attributed perception of climate change to other farm, household and institutional factors such as farm income, age of farmers and access to support services.

Various studies conducted for African farming systems indicated that those farmers with extensive experience in farming were more likely to notice local climate change and take measures to adapt than those with limited farm experience (Maddison, 2007; Silvestri et al.,

2012). This greater perception of experienced farmers is mainly linked to their ability to detect over time the impact of climate change on sensitive rainfed production systems and associated livelihoods. In contrast, Gbetibouo (2009) reported no statistical difference between experienced and inexperienced farmers in South Africa.

The financial well-being of African farmers is reflected by the combination of their farm and non-farm incomes and strongly influences their ability to bear farming-related risks such as climate change (Belaineh et al., 2013). It has been reported that both farm and non-farm income levels dictate farmer perception of climate change and its impacts (Deressa et al., 2011; Osbahr et al., 2011; Ndambiri et al., 2012). In particular, non-farm income has the potential to buffer farm income losses and these farmers are less likely to be aware of climate change and its associated impacts on local agriculture. Financial well-being, however, is not always reported as influencing climate change perception. In a study of Kenyan farmers, they did not appear to be influenced by either their farm or non-farm income (Silvestri et al., 2012).

Traditional farmers in Africa depend on extensive grazing and traditional livestock feeding systems that are strongly reliant on natural resources with little or no alternative feeding strategies (Davies et al., 2010). The availability of these resources are closely tied to local weather conditions and as such, any fluctuations in climatic conditions will have implications on the availability of these natural resources(Osbahr et al., 2011). Research has shown that livestock ownership can increase the propensity of discerning climate risk and the likelihood of adopting adaptive measures (Lesnoff et al., 2012; Belaineh et al., 2013).

Different agroecologies embrace various agricultural production and management systems that demonstrate different degrees of vulnerability and elicit different responses to climate change (Kassie et al., 2009). Deressa et al. (2011) reported that local agroecological conditions significantly influenced how farmers in the Nile basin of Ethiopia discern local changes in climate. As might be expected, farmers in inherently low rainfall and moisture stress areas discern changes in climate more readily than their counterparts in high rainfall areas.

Access to climate information is hypothesized to improve the climate change awareness of African farmers as it makes information on past, present and the future climate available for farmers' utilization and decision-making (Hassan and Nhemachena, 2008; Silvestri et al., 2012). Bryan et al. (2009) reported that in Ethiopia and South Africa access to accurate climate forecasts improved farmers' awareness of and adaptive responses to climate change risk. Lack of climate early warning systems and unreliability of seasonal forecasts in Ethiopia were found to be barriers to awareness and adaptation actions (Deressa et al., 2011; Gandure

et al., 2013). Extension services in Africa (training days, workshops, farm visits, farmer-to-farmer exchange visits and the setting up of farmer research groups) facilitate the sharing of different perceptions, experiences and types of decision making (Hassan and Nhemachena, 2008; Silvestri et al., 2012). However, this context for the sharing of useful information is often limited as there is poor institutional capacity to deliver extension services (Maddison, 2007).

Claims by farmers of climate change expressed in terms if increased temperatures or less rainfall may or may not be substantiated by meteorological evidence. In case studies from Uganda Osbahr et al. (2011) and the Limpopo River Basin, South Africa Gbetibouo (2009) claims made by farmers in terms of increased temperature and variability in rainfall did tally with meteorological evidence and that local climate has shifted to a less favourable one for agricultural production. In contrast, Maddison (2007) reported that climate change perception of African farmers did not tally with evidence from weather monitoring stations. Both Maddison 2007 and Patt and Schröter (2008) suggests that the mismatch between the farmers' perception of climate change and evidence from climate records suggests that farmers are more influenced by past experience and future uncertainty than actual climate data. There are two important caveats that should be considered when comparing perceived change against observed meteorological records, particularly for Africa (Maddison, 2007; Zampaligré et al., 2014).

The first caveat is that significant climatic events within a given study period can be obscured because climate change is determined from changes in average conditions based on long-term climate records. For instance, farmers are arguably better positioned to recall past extreme events such as floods, hurricanes and droughts than average long-term climate trends (Osbahr et al., 2011). The second caveat is that climate change analyses often use data from scattered meteorological stations and tend to hide spatial heterogeneity across microclimates. Microclimates created by variation in topography, large bodies of water and soil type can significantly modify the climate. The task of understanding gets even more difficult when climate scientists sometimes provide conflicting reports on similar issues (Bryan et al., 2009; Raymond and Robinson, 2013).

2.4 Options for and barriers to adaptation in Ethiopian agriculture

2.4.1 Approaches to adaptation

Adaptation is defined as the process of adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects which moderates harm or exploits beneficial opportunities (IPCC, 2014). The frequency and intensity of adverse impacts of climate change are important determinants of adaptation decisions, and the range of risks vary with individuals or groups capacity to adapt and time. The range of risks change with capacity and attitude towards risk. There are acceptable levels of risk which do not justify adaptation as frequency of adverse impact is low and/or intensity becomes negligible. Adaptation adjustments are thus intended to limit climate-induced risks to objectives within a tolerable range between limits of acceptable risk and adaptation limit beyond which adjustment is not possible (Klein et al., 2014) (Fig. 5). The risks become intolerable as affordable adaptation become unavailable. Adaptation adjustments can be large or small in scale, short-term or long-term in time scale which all depends on various factors including adaptive capacity and adaptation goals.

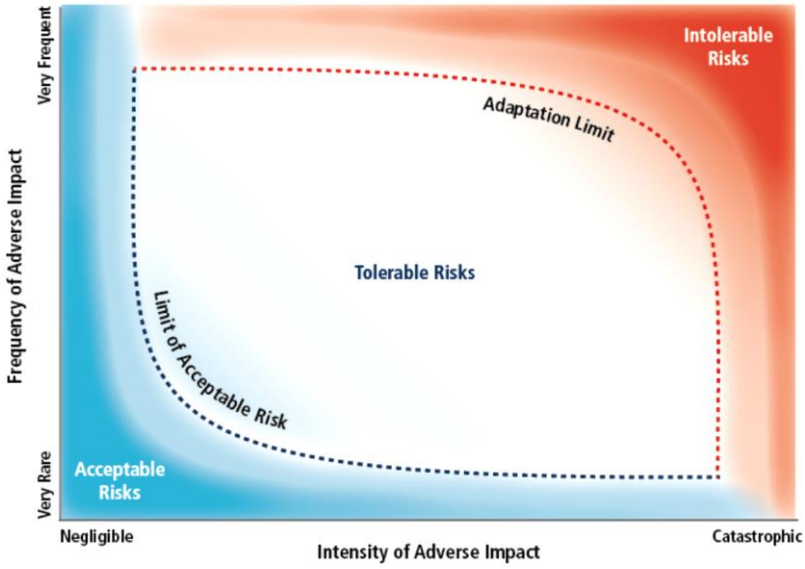

Figure 5. A conceptual model of determinants of acceptable, tolerable and intolerable risks and their implications to limits to adaptation (Klein et al., 2014)

Adaptation can be categorized into spontaneous (autonomous) or planned. It can be anticipatory (proactive), concurrent (during) or responsive (reactive) in terms of timing with reference to the climatic stimuli (Pelling, 2011; IPCC, 2014). Adaptation options can take a variety of forms (technical, policy or institutional), occur at a variety of spatial scales (global,

regional and local), temporal scales (short, medium and long-terms) and be linked to climate drivers in different ways (reactive, concurrent or anticipatory) (Smit et al., 2000; Pelling, 2011). Some options might have mixed results and can lead to insufficient adaptation or maladaptation which may increase vulnerability across spatial and temporal variants (Barnett and O'Neill, 2010; Eriksen et al., 2011).

Many decisions concerning long-term investments need to take into account future climate change. Methods of doing this were categorised by (Hallegatte, 2009); no-regret options which provide benefits even in absence of expected climate change; favouring of reversible and flexible options over irreversible options; creating low cost "safety margins" in new investments, especially important for adaptation measures that are not reversible or flexible; soft institutional and financial tools such as land-use plans, insurance schemes or early warning systems and strategies to reduce decision-making time horizons such as in forestry the growing of species which require shorter rotations. In practice, it is difficult to make clear distinctions among Hallegatte's categories which have their own strengths and weaknesses.

Successful adaptation requires appropriately defining and assessing climate change both as a problem and context. Climate risk assessment for adaptation planning can take two different but complementary approaches - the top-down (scenario-led) and the bottom-up (vulnerability-led) methods (Wilby and Dessai, 2010; Noble et al., 2014). The top-down approach of risk assessment takes into account the impact of climate change under a range of greenhouse gas emission scenarios and employs predictive climate and impact models. Often called the "standard approach", the top-down approach involves downscaling large scale climate change projections to local level, and impact modelling to estimate the likely impact of those projected future climate scenarios (Noble et al., 2014). This approach is widely represented in the scientific evidence of climate change impact given by the IPCC. Nonetheless, there are very few examples of adaptation planning and decisions arising from this particular route in the practical world (IPCC, 2013). though it remains informative of anticipated climate change and its potential risk. Uncertainty around future climate scenarios means that the use of climate and impact models as an input to adaptation planning brings a level of risk to investment which may not be acceptable.

The bottom-up approach starts with an analysis of vulnerability elements including underlying factors that enable or constrain successful adaptation to past, current or future climate change. It begins at a local scale and is location-specific in its approach to climate risk assessment (Noble et al., 2014). The vulnerability-led approach recognizes that there are important climatic attributes that systems are sensitive to, and these attributes can be used to

analyse implications of changing climatic conditions to specific systems and livelihoods with specific adaptive capacity (Smit and Skinner, 2002; Wilby and Dessai, 2010). The bottom-up approach presents a practical framework to address the local vulnerability of systems and livelihoods through pragmatic risk management approaches. The strength of this approach is that it focuses on the root causes of vulnerability and enables well targeted adaptation.

Debates on the relationship between agricultural adaptation and climatic stimuli increasingly recognize that adaptation to climate change encompasses not only changes in long-term mean conditions, but also climate variability. i.e. interannual variations in local growing season conditions and the magnitude/frequency of extreme events (Smit et al., 1999; Smit and Skinner, 2002; IPCC, 2013). Relationships between short-term adaptations to climatic variability (which contribute to long-term climate change) and long-term adaptation to changing mean conditions is complex and ambigous (Doria et al., 2009). It has been suggested that focusing on short-term adaptation to climate extremes may compromise the ability to engage in long-term adaptation. Adaptation of farming systems to environmental changes especially changes in climate has been occurring for generations of vulnerable farming communities around the world. For example, pastoralist communities living in dryland regions characterized by more climate variability have been making more efforts to cope with impacts and adapt to changing climatic conditions (Dong et al., 2011). In general, most of the adaptation to climate variability and change in Africa is reactive in response to short-term motivation, is autonomous occurring at the individual or household level, and often lacks government and policy support (Ziervogel et al., 2008; Berrang-Ford et al., 2011; IPCC, 2014). Despite ongoing efforts, whether those adaptations were effective or not is questionnable.

Adaptation in agriculture can occur at different spatial scales that include individual plant, animal, plot, field, farm, region, national and global levels which feature distinctive adaptation processes and outcomes (Smiths et al., 1997; Smit and Skinner, 2002). These scales are critical in shaping routes of adaptation, processes and outcomes. Risbey et al. (1999) categorise agricultural adaptation decisions based on their time-frame and probable outcomes: tactical (seasonal, <1 year); strategic (multiple years, 1-5 years) and structural (multiple decades, >5 years) decisions. All three time frames involve different adaptation actors with different perspectives, vulnerabilities and adaptation needs. Howden et al. (2007) describes mainly tactical decisions at the management unit as key components in adapting agriculture to climate change. He outlined a range of such adaptations for cropping, livestock, fishery, and forestry systems e.g. altering inputs such as crop varieties to those with more appropriate

thermal time and vernalization requirements, modification of times of grazing, and timing of reproduction. Adaptation decisions at this management unit level can be strongly influenced by other levels of decisions e.g. new policies to invest in technologies and infrastructure which will facilitate effective adaptation.

The concept of adaptation is deceptively simple but the reality is complex. Adaptation to climate change does not occur in isolation from the direct or indirect influence of non-climatic forces such as social, economic and institutional environments which create a specific context for significant human-environment interaction (Smithers and Smit, 1997; Mertz et al., 2009b). The complexity of ongoing pervasive changes in both climatic and non-climatic forces (Nielsen and Reenberg, 2010), as well as the increasing magnitude and frequency of climate change means there is now a greater sense of urgency to adapt.

2.4.2 Adaptation options in response to climate change

Adaptation needs and options

Adaptation needs are the gap between what might happen due to climate change and what we desire to happen in the face of actual or anticipated climate in the future. Adaptation needs, therefore, emerge when actual or anticipated risks or experienced impacts from climate change require a different action to ensure safety of livelihoods, security of assets and ecosystems and their services (Mahrenholz, 2008; Noble et al., 2014). In general, adaptation needs are categorised as bio-physical and environmental, social and institutional (Noble et al., 2014). In terms of stimuli, Fussel (2007a) states that the need to adapt often arises, but not always, from extreme climatic conditions rather than average climatic conditions that manifest over a longer time-frame. Mertz et al. (2009a) reported that rapid adaptation is more needed in developing countries than developed counterparts; not only because of differences in current and projected change but also because of higher vulnerability and lower adaptive capacity in developing countries.

Adaptation options are defined as the array of strategies and measures that are available and appropriate for addressing adaptation needs, and include wide range of actions that can be categorized as structural, institutional, or social (IPCC, 2014). There are many different ways that the range of adaptation options available can be categorized (Smit and Skinner, 2002), and Noble et al. (2014) take into account the diverse adaptation options for different sectors and stakeholders and categorise adaptation options as structural/physical, social or institutional. These authors admit that any categorization is unlikely to be universally agreed upon.

Structural adaptation options are well defined in scope, space and time and include the structural and engineering options (e.g. sea walls and coastal protection structures), the application of discrete technologies (e.g. efficient irrigation), the delivery of specific services (e.g. municipal services including water and sanitation) and the use of ecosystem services to serve adaptation needs (e.g. adaptive land use management)(Noble et al., 2014). The social category incorporates educational, informational and behavioural measures such as awareness raising, early warning and response systems and livelihood diversification. This social category further includes social-protection schemes that transfer income or assets within and across social groups, and farmer-to-farmer training and information sharing practices. Institutional options include economic instruments that range from taxes, subsidies, and insurance arrangements to social policies and regulations. The processes and outcomes linked to these options vary with sector and stakeholder and more broadly depend on complex adaptation environments.

Studies conducted across rural communities in developing countries indicate that smallholder farmers use a range of adaptive measures to pursue agricultural adaptation. In rainfed agriculture these adaptation strategies have evolved over generations to overcome year-to-year and season-to-season uncertainties in climate, mainly rainfall (Gebrehiwot and Veen, 2013). In a study from Sri Lanka, strategies were broadly categorized into five groups: crop management (e.g. used mulches, changed crop variety, changed crop type); land management (e.g. soil conservation, reduced tillage, shifting cultivation); irrigation management (e.g. increased use of water conservation, rainwater harvesting); income diversification (e.g. off-farm employment, leased cropland, shifted from crop to livestock) and rituals (e.g. normative behaviours, rituals and various other practices to invoke the blessings of the gods to cause rainfall in the dry months and to increase crop endurance to face adversities) (Esham and Garforth, 2013).

Coping strategies have been particularly designed to mitigate or buffer against the negative impacts of poor rains and often fail to exploit the beneficial opportunities presented by climate change (Cooper et al., 2008). The author underlines that farming communities have the tendency to underestimate the opportunities and over-estimate the negative impacts of climate variability and change. As a result, most farmers remain poor and vulnerable to risk and uncertainty linked to the future climate. Most of the adaptive options employed by smallholders in Ethiopia are characterized by short-term low external input measures reflecting the weak adaptive capacity of these resource-constrained small-scale farmers and their pastoral counterparts.

2.4.3 Maladaptation

The IPCC's Fifth assessment report defines maladaptation as the situation in which adaptation actions may result in increased vulnerability to climate change, and risk of adverse climate-related outcomes or diminished welfare, now or in the future (IPCC, 2014). In a similar way, Barnett and O'Neill (2010) defined maladaptation as ''action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on, or increases the vulnerability of other systems, sectors or social groups.'' In practice, adaptation decisions taken to benefit one group or sector may undermine the livelihood and security of others by affecting access to resources and integrity of ecosystems which support livelihoods(Eriksen et al., 2011). Maladaptation has also been described as a condition whereby adaptive actions could result in negative effects that are as serious as the climate-induced effects being avoided by that action (Scheraga, 1998). In general, it denotes that decisions may fail to meet objectives and even become unsuccessful or result in undesired outcomes on other groups or societies.

Historically, adaptation efforts were devised to mitigate the negative impacts of climate change, and the possibility of adaptation actions increasing vulnerability was not considered until the early 1990s. However, there are clear instances when adaptive decisions or actions have failed to meet the intended objectives resulting in undesired outcomes and a shift towards maladaptation often increasing vulnerability (Barnett and O'Neill, 2010). For example, Heyd and Brooks (2009) reported massive development aid efforts that actually increased exposure and vulnerability to climate variability and change in the Sahel region of Africa. This was mainly due to the fact that the development approaches undermined the traditional way of resource governance and increased competition for resources. That intervention in one sector or system could potentially increase vulnerability and unwanted outcomes in other sectors or systems has been a cause for increasing concern among adaptation planners and practitioners (Adger et al., 2003).

Various studies have identified two major causes of maladaptation: 1) when actions that may benefit a particular individual, group, system or sector over a particular time frame may turn out to be maladaptive for the same or other individuals, groups, systems or sectors (Barnett and O'Neill, 2010; Eriksen et al., 2011), and 2) a failure to consider multiple interactions between adaptation units and misguided information that result in inappropriate adaptive responses and strategies (Smithers and Smit, 1997; Noble et al., 2014). Thus externality and path-dependency, respectively are important causes of maladaptation.

In a case study, Barnett and O'Neill (2010) identified five distinct pathways for maladaptation to be manifested: 1) an increase in emissions of greenhouse gases, 2) a disproportionate burdening of the most vulnerable, 3) an incurrence of high opportunity costs, 4) a reduction in incentives to adapt, and 5) a limitation in choices available to future generations. Barnett and O'Neill (2010) used these five pathways to evaluate two schemes to reduce water shortage in Melbourne, Australia (a desalinization plant and water piped from a dam). The study concluded that these two schemes to adapt to water shortage exhibited all five dimensions of maladaptation although the assessment should be considered with caution as it depended on a fairly subjective evaluation. In another case study, Homann et al. (2008a) found that an adaptive action (water developments in rainy-season grazing areas, Did Hara, Ethiopia) increased the vulnerability of neighbouring pastoralist communities, limiting the seasonal mobility of livestock into previously wet-season pasture reserves. A top-down interventionist approach initiated by the Ethiopian government led to a maladaptive water development that undermined indigenous resource-governing regimes.

Pastoralist communities across African dryland regions have been striving to adjust to pervasive changes in socioeconomic, biophysical and institutional factors. However, adaptation efforts have led to variable outcomes and achieved unwanted results. For example, adaptation efforts in east African dryland systems have led to the exploitation of resources and increased resource-based conflicts. Similarly, short-term efforts by pastoralists to overcome drought-induced stresses resulted in long-term resource-based conflicts in Northern Kenya (Galvin et al., 2009). In turn, this maladaptation restricted the future access to these natural resources, limiting livelihood adjustment options and constraining local adaptation strategies. Finally, the expansion of agriculturalists into neighbouring pastoralist regions as an adaptive strategy has resulted in an increased social conflict among two groups in the Sahel region (Dong et al., 2011). The emergence of such conflicts has been attributed to rapid economic and political transitions, which have forced farmers to expand into marginal areas.

2.4.4 Barriers to adaptation

Unsuccessful adaptation in vulnerable communities has prompted research to gain a better understanding of the nature and form of barriers that constrain adaptation and identifying entry points for appropriate remedial action (Nielsen and Reenberg, 2010). In particular, adaptation deficit in developing nations triggered focused research on barriers (Moser and Ekstrom, 2010). Adaptation barriers can arise at different stages of the adaptation process and be related to environmental, economic, informational, social, attitudinal, or behavioural

factors (Howden et al., 2007) although emerging research on barriers has largely emphasized the natural, financial and technological categories and given less attention to the social elements (Nielsen and Reenberg, 2010; Jones and Boyd, 2011). Socio-cultural barriers may not always be acknowledged but in practice these elements play important roles in limiting adaptive capacity and impede adaptation.

Researchers have often used the terms barriers and limits interchangeably though these concepts are markedly different in terms of meaning. Moser and Ekstrom (2010) defined barriers as obstacles that can be overcome with concerted effort, creative management, change in thinking, shifts in resources, land uses and institutions. Barriers can be abated or mitigated using corrective measures through human action (Moser and Ekstrom, 2010). In contrast, limits are referred to as obstacles that tend to be absolute in a real sense and which constitute immutable thresholds beyond which existing activities, land uses, ecosystems, species, sustenance, or system states cannot be maintained, not even in a modified fashion (Adger et al., 2009; Moser and Ekstrom, 2010).

Barriers to adaptation are broadly grouped into three major categories (Jones and Boyd, 2011); 1) natural - bio-physical processes that govern ecological and physical constraints e.g. shortage of land, degradation of rangelands and lack of access to irrigation water, 2) social - local norms, behaviours, values and their processes, and 3) human/informational - low levels of awareness, uncertainties associated with climate forecasts and information available to policy makers, researchers and practitioners (Adger et al., 2009; Nielsen and Reenberg, 2010). These all present unique set of challenges to successful adaptation (Fig. 6).

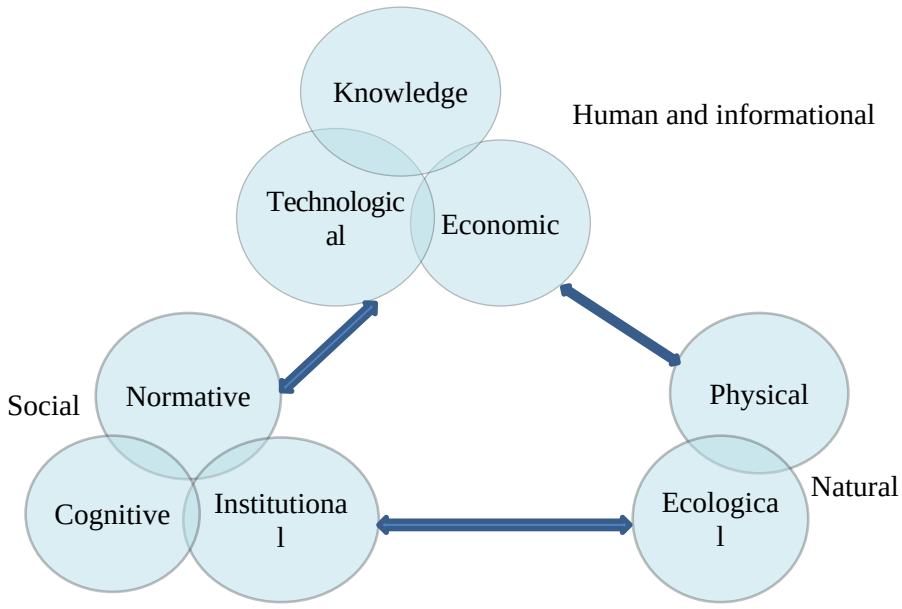

Figure 6. Barriers and limits to adaptation and their inter-relationships (Jones and Boyd, 2011)

While barriers and limits constrain adaptation, both are considered endogenous to society and shaped by prevailing ethics, knowledge and attitude towards risk and culture. For example, restrictive social institutions in western Nepal limited the range of adaptation options available. Individuals who deviate from the socially acceptable adaptation options are ostracised (Jones and Boyd, 2011). Similarly, Nielsen and Reenberg (2010) reported that cultural barriers limited adaptation options by impeding a local group in Northern Burkina Faso from involving themselves in a particular livelihood activity. The authors underlined that, for the *Fulbe* ethnic group in West Africa, cultural barriers have impeded the embracing of successful livelihood strategies such as working for development projects, labour migration, gardening and the engagement of women in income generating economic activities. It is critical to understand and address the complexity of barriers at play to improve adaptive capacity and adaptation outcomes under heterogeneous socioeconomic and biophysical settings.

2.5 Institutional aspects of adaptation to climate change

2.5.1 Theory of social institutions

Institutions are important aspects of adaptation to climate change as they provide persistent social structures and the mechanisms of social order. There have been different approaches for defining institutions and as such there is no single and universally agreed upon definition of institutions. Dovers and Hezri (2010) defines institutions as ‘‘predictable arrangements, laws, processes or customs serving to structure political, social, cultural or economic transactions and relationships in a society’’. The definition draws attention to the role institutions play in promoting organized, collective efforts toward meeting common challenges, mediating/reconciling differences among individuals and social groups, and achieving shared goals. Ostrom (1990) again defined institutions as humanly created formal and informal mechanisms that shape social and individual expectations, interactions, and behaviour. The definition emphasizes the role of institutions in structuring and shaping outcomes through decisions taken by individuals and/or social groups as affected by internal processes and external relationships.

Alternatively, institutions can be conceptualised as sets of enduring ideas, rules (formal and informal), norms and practices (*de jure* and *de facto*) as well as organizations and decision-making groups (Watson, 2003). As such institutions, in this case, are structures of power that shape social and individual expectations, interactions, and behaviour. Lastly,

O'Riordan and Jordan (1999) refers institutions as the means for holding society together, giving it a sense of purpose, and enabling it to push for collective interests including adaptation. The definition emphasizes the role of institutions in defining climate change both as a problem and context of the collective interest of a society.

Despite inherent differences amongst institutions, as structures and mechanisms they all share two key characteristics. The first is that institutions are not immutable, rather they are fluid and dynamic evolving over time in response to changing social, economic, environmental and political realities (Upton, 2012). The second key characteristic is that they are social in nature and arise due to the collective interest and activities of individuals and groups within a society (Agrawal and Perrin, 2008). Determining the direction and magnitude of flow of resources between social groups is one of their important roles.

Typology of institutions

Institutions are structures and mechanisms created by humans that shape the expectations, interactions, and behaviour of individuals, groups and societies. Though there is no universally agreed upon classification system, institutions can be broadly classified based on different criteria. Institutions can be;

- formal (laws, treaties, policies, regulations) or informal (norms, codes of conduct and informal regulations) based on how they are introduced and enforced by state and non-state actors (Ranganathan et al., 2010).
- civic (membership and cooperative organizations), public (bureaucratic administrative units, and local governments) or private (service and business organizations) (Uphoff and Buck, 2006; Agrawal and Perrin, 2009); local, regional or global depending on their jurisdictions and spatial scales or levels they cover; sector-specific or multi-sectoral ones based on if they are limited to a particular sector or transcend across multiple sectors; and could be urban or rural based on economic and geographic frame of reference (Agrawal and Perrin, 2009), and
- indigenous or introduced, based on whether they are externally introduced or emerged/evolved from within through ongoing internal or external processes, and changing needs of societies.

Indigenous institutions are important and highly valued structures among societies particularly with traditional communities where collective lifestyle is common. The word indigenous often has a significant overlap with the words 'local' or 'community-based'

(Agarawal, 2008). Indigenous institutions can thus refer to those that have emerged in a particular situation or that are practiced or constituted by people who demonstrate a considerable degree of continuity of living in and using local resources including customary rules or traditional knowledge (Watson, 2003). Indigenous institutions are those institutions internally established or evolved based on collective experiences and management skills of local or indigenous people living in rural farming communities (Makepe, 2006). They play critical roles in determining how different social groups, such as vulnerable ones, gain access to assets and resources. Indigenous institutions typically constitute customary rules, norms, conventional knowledge and regularized practices which promote shared societal goal and collective interest (Homann et al., 2008b). They are particularly valuable in terms of echoing of indigenous concerns and values that underpin human decision-making in adaptation and development.

Like many other traditional farming systems, the Borana pastoral and agropastoral systems of Ethiopia have institutional landscapes that shape resource management, adaptation and livelihoods (Fig. 7). For example, in Borana, the *Gada* system which is the overarching traditional institution, is responsible for overseeing the traditional lifestyle of pastoralists and agropastoral communities in the Borana society through making and amending customary laws (Tache, 2008). The *Gada* system represents complex, resilient and still flourishing indigenous institution (Bassi, 2005) which its various structural components help to address different aspects of societal problems including natural resource governance, vulnerability, livelihood support and tenure issues. In particular, the traditional system presents customized effective natural resource management regime which allows integrated management of rangelands and water points. Particularly, through climate extremes it provides management system that determines access to resources for individuals and social groups. In this regard, the resource management regime divides the entire rangelands across Borana into grazing-based administrative units called *madda* which are configured around permanent water points (Fig. 7). The *madda*s are again divided into local sub-grazing units called *arda*, which constitutes few encampments called *olla* which constitutes around ten farm households (Kamara et al., 2004). The *olla* makes the lowest traditional administrative unit and has strong jurisdiction over surrounding natural resources including cultivated lands, grazing fields and water points.

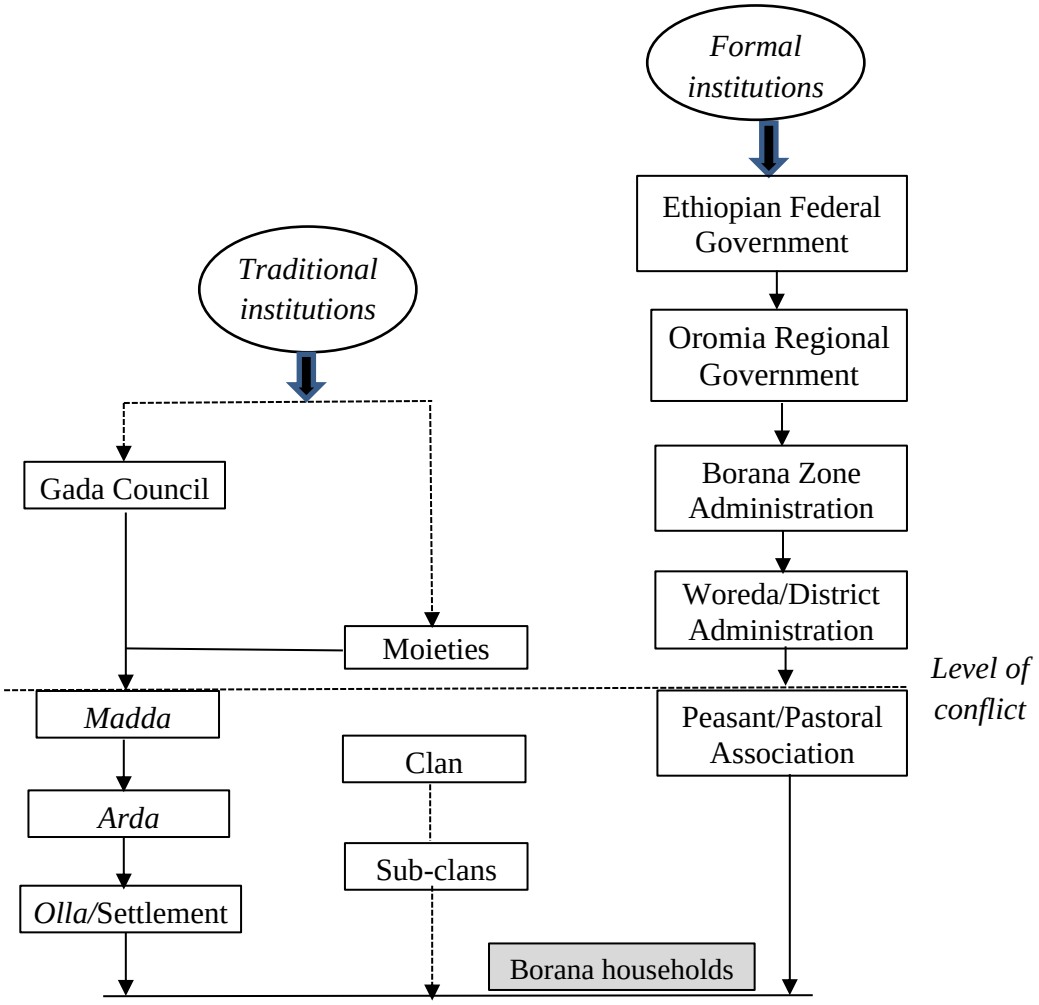

Figure 7. The institutional linkages in the Borana lowlands of southern Ethiopia (Kamara et al., 2004)

Inevitably, the traditional institutions of the Borana community are one of the most strong in east Africa and interact with their formal counterparts at various scales. However, there have been conflicts of interests at different administrative units between traditional and formal institutions particularly those involving resource management and local governance (Watson, 2003; Kamara et al., 2004). This is because state institutions and their structures have competing roles and interests in resource management and governance. The trust and support indigenous institutions enjoy at the local level makes them more valuable and assertive. For example, the divergence in the land tenure system can be considered a good example of an institutional interaction related to resource governance (Homann et al., 2008a). However, tensions between state and indigenous institutions are anticipated to exist and evolve as long as realities on the ground keep changing.

2.5.2 The institutional context of adaptation to climate change

Institutions constitute one of the most important actors in adaptation to climate change. Institutions play vital roles in shaping adaptation responses, prescribing routes for adaptation and determining socially just adaptation outcomes, has received important attention by policy makers (Agrawal and Perrin, 2009; Upton, 2012). The institutional landscape for climate change adaptation encompasses a wide spectrum of institutions that serve different purposes and work at different scales. The landscape may include endogenous, national/regional government structures, global platforms and donor-initiated institutions (Watson, 2003; Upton, 2012). Institutions can play various roles including providing funding and technical support, facilitating access to resources and mediating diverging interests of different actors. Indigenous institutions are recognised as having a longstanding role in local governance of common pool resources and addressing vulnerable segments of the society across traditional communities around the world (Upton, 2012). Therefore, enhancing institutional capacity and exploiting its potential in enabling adaptation remains a key task for adaptation planners.

Interrelationships and interactions between different social actors (e.g. people, farm households, businesses) and institutions (formal and informal) are multi-dimensional and occur at different spatial and temporal scales (Berkhout, 2012). These interrelationships and interactions are often guided by top-down higher level state-owned policy institutions which tend to dictate the platform for local actors to navigate adaptation (Rodima et al., 2012). Local institutions however can play vital roles in channelling external resources and determining access for resources by different social groups particularly those vulnerable and disadvantaged ones. Institutions are thus important elements of adaptation because they can play enabling or constraining roles in adaptation to climate change.

Mainstreaming adaptation into development planning

There is a vital link between adaptation and development. This relationship implies that climate change can impede the ability to achieve development whilst development can reduce vulnerability to climate change (Bisaro et al., 2010). Baudoin (2013) suggests that instead of applying separate adaptation programmes, it is important to put an emphasis on mainstreaming adaptation within existing development programmes and policies. He argued that many development projects have achieved positive results in terms of adaptation strategies as they address local need and realities.

There is an increasing need to mainstream adaptation in the policies and programs for developing countries (Mertz et al., 2009a; Dovers and Hezri, 2010). Emphasis has been given to both the vertical (across political and organizational scales involving national, provincial/state, and local institutions) and the horizontal (cross-sectoral) integration of adaptation into development planning. The mainstreaming of adaptation into development has been promoted by the understanding that, at different scales, adaptation affects development and development affects adaptation (Galvin et al., 2009). Vulnerability is therefore affected by both adaptation and development. There is an increasing level of awareness of the importance of enhancing an individual household's ability to address vulnerability to livelihood fluctuations while also improving economic development and the total welfare package for all households Agrawal and Perrin (2009). Therefore, integrating adaptation and livelihood enhancement goals will help to create the synergy.

In developing countries, poverty alleviation and climate change adaptation goals have become inseparable institutional processes due to the policy priorities to achieve food security and livelihood improvement (Virtanen et al., 2011). For example, Galvin et al. (2009) reported the adjustment to multiple shocks and stresses such as climate-induced conflict and drought in Kenya is intrinsically a political and institutional process. The study indicated that individuals and communities form social relations and political alliances to influence collective decision-making as a way to increase livelihood adjustment options and promote particular adaptation interests. Similarly, Virtanen et al. (2011) argued that engaging local institutions was the most effective way to adapt as they are well placed in local circumstances and have capacity to mobilize local resources. In a similar study, collective adaptive action by rural communities enhanced livelihood resilience to climate change among small-scale farmers in South Africa, despite the negative spillover effects to neighbouring areas (Osbahr et al., 2010). In general, the achievement in terms of improved resilience has been partly attributed to social networks, institutions and innovation within the context of climate change adaptation (Homann et al., 2008a; Upton, 2012). Thus, integrating adaptation and development becomes an inevitable priority among policy planners and practitioners.

2.5.3 Role of indigenous institutions in adaptation to climate change

Indigenous or local institutions are important elements of adaptation and play pivotal role in influencing adaptation and improvement in local livelihoods through providing norms, values, rules and indigenous knowledge (Agrawal and Perrin, 2009). The growing attention towards a better understanding of institutional arrangements for natural resource management and

climate change adaptation has been partly in response to past failures in underestimation and isolation of the role indigenous institutions play in resource governance (Yami et al., 2009). In this regard, understanding the nuanced role of indigenous institutions in assisting social resilience and livelihood adaptation remains sketchy in the literature.

Indigenous institutions remain central to climate change adaptation and livelihood improvement across traditional farming systems in developing countries reliant on agriculture-based livelihoods. In this regard, indigenous institutions have been actively providing traditional knowledge and mechanisms about vital areas such as resource governance and climate forecast (Homann et al., 2008a; Speranza et al., 2010). For example Yami et al. (2009) reported that informal institutions contributed to management of common property resources in the Tigray region of Northern Ethiopia. The authors argued that these institutions created enabling governance environment for collective decision-making, enabling exclusion at low cost for resource users and enacting locally agreed upon sanctions in favour of collective interest. It is apparent that these institutions helped to reverse degradation of common property resources between competing actors. Ostrom and Basurto (2010) reported the importance of local norms and rules to manage access to irrigation water among the Nepali irrigators. Here local institutions played pivotal role in water governance by providing incentives, shaping behaviours and favouring improved outcome. Moreover, integrating formal rules into local and indigenous institutions through local ecological and social knowledge was suggested to give a better chance of producing improved results.

Agrawal and Perrin (2009) claimed local institutions influence adaptation and rural livelihoods in three important ways;

- structuring vulnerability and the distribution of climate risk impacts,
- establishing incentive structures for household/community level adaptation responses, and
- mediating external interventions in a local context.

Institutions influence adaptive capacity and adaptation outcomes. Berman et al. (2012) reported that institutions played pivotal role in mediating the transformation of coping capacity into adaptive capacity. For example, in rural areas of Benin, state institutions were found unable to support adaptive capacity of small-scale farmers due to a lack of trust and credibility in state institutions by farmers (Baudoin, 2013). Instead, non-governmental organizations such as local institutions were better positioned to support agricultural adaptation than state structures. In a similar study, endogenous institutions played a

significant role in shaping pastoralist's adaptive capacities and responses in Mongolia's Gobi region while the efficacy of state institutions was widely criticized by herders (Upton, 2012). The author underlined the transformation of the institutional framework that regulates resource management as key to responding to changing local needs and realities.

Indigenous institutions have proven to be instrumental in facilitating adaptation by contributing in key areas of agricultural adaptation through providing climate forecast, resource governance and mediating information exchange (Homann, 2004; Ashenafi and Leader-Williams, 2005; Green and Raygorodetsky, 2010; Speranza et al., 2010). For example, indigenous knowledge was found to provide a basic knowledge framework within which pastoralists performed climate forecast and associated early warning systems in semi-arid areas of Kenya (Speranza et al., 2010; Washington-Ottombre and Pijanowski, 2013). The climate forecasts were found to be translated into meaningful changes in climate change adaptation planning and practice. In a similar case study, Gómez-Baggethun et al. (2012) reported that traditional ecological knowledge played a critical role in governing natural resources necessary for adaptation to climate change in the Donana region of Spain. In all the studies mentioned above, the traditional knowledge and associated institutions played a crucial role in improving socio-ecological resilience, adaptive capacity and adaptation among rural communities.

Indigenous institutions in Borana are important elements of everyday life and provide a means to promote development that addresses local needs and priorities including adaptation to climate change. In particular, the indigenous natural resource management institutions are seen as valuable resources in order to achieve adaptation and development goals (Watson, 2003; Kamara et al., 2004). Resource governing institutions are important in determining access to common property resources for different social groups. However, certain national policies on rural development have resulted in a conflict of authority between traditional and formal institutional systems in the Borana affecting natural resources management and adaptation outcomes (Kamara et al., 2004; Homann et al., 2008a). This conflict has arisen mainly due to the tension over sociocultural and resource governing regimes which are important to the Borana society but having overlapping mandate with the state governance structures. This study will, therefore, examine the role indigenous institutions play in influencing adaptation to climate change.

2.6 Research directions

This literature review has highlighted the high level of vulnerability to climate change in African smallholder agriculture particularly in Ethiopia. Farming systems across dryland systems are facing especially variable climatic conditions. Given this high degree of vulnerability, Ethiopian smallholders, such as the pastoralists and agropastoralist of the Borana, have been making efforts to adapt to climate change and overcome its adverse effects but the climate-induced risk to their livelihoods remains high. This literature review has indicated how specific types of information will assist in gaining insights into how to improve climate change adaptation policies and interventions for traditional smallholder farmers in Ethiopia. Better understanding of the local views or perception of climate change, a bottom-up investigation of existing adaptation efforts, options and existing barriers will ensure focused and workable solutions for successful adaptation especially if the role of local institutions in facilitating this adaptation is adequately captured and no longer ignored.

Chapter 3: Perception of climate change and its impact by smallholders in pastoral/agropastoral systems of Borana, South Ethiopia

Abstract

This study investigated the perception of historic changes in climate and associated impact on local agriculture among smallholders in pastoral/agropastoral systems of Borana in southern Ethiopia. We drew on empirical data obtained from farm household surveys conducted in 5 districts, 20 pastoral/agropastoral associations and 480 farm households. Using this data, this study analysed smallholder perception of climate change during a 20 year study period (1992-2012) and its associated impact on local agriculture, and the effect of various household and farm attributes on perception. Results suggest that most participants perceived climatic change and its negative impact on agricultural production and considered climate change as a salient risk to their future livelihoods and economic development. Different levels of perception were expressed in terms of climate change and the impact on traditional rain-fed agriculture. Age, education level, livestock holding, access to climate information and extension services significantly affected perception levels. Household size, production system, farm and non-farm incomes did not significantly affect perception levels of smallholders. Smallholders attributed climate change to a range of biophysical, deistic and anthropogenic causes. Increased access to agricultural support services, which improves the availability and the quality of relevant climate information will further enhance awareness of climate change within the rural community and result in better management of climate-induced risks in these vulnerable agricultural systems.

3.1 Introduction

Perception strongly affects how farmers deal with climate-induced risks and opportunities, and the precise nature of their behavioural responses to this perception will shape adaptation options, the process involved and adaptation outcomes (Adger et al., 2009; Pauw, 2013). Misconception about climate change and its associated risk may result in no adaptation or maladaptation thus increasing the negative impact of climate change (Grothmann and Patt, 2005). Perception of climate change consistent with the actual change is important for adaptation planning.

Rural households in sub-Saharan Africa are heavily reliant on their natural resource base to provide food and income for the family, and the availability of such resources is dependent on favourable seasonal weather conditions (Solomon et al., 2007). In the climatically more

variable regions of sub-Saharan Africa, where dryland farming systems are common, the heavy reliance on rainfed agriculture increases the vulnerability of rural households to the adverse impacts of climate change (Thomas et al., 2007; Mertz et al., 2009b). Resource-poor farmers have limited capacity to adapt and are particularly vulnerable (Antwi-Agyei et al., 2012). In Ethiopia, agricultural production is predominantly rain-fed and irrigated agriculture constitutes only 1.1% of the total cultivated land (Bewket and Conway, 2007) and less than 3% of the current food production in the country (Awulachew et al., 2005). Pastoralism in Ethiopia represents about 60% of the land mass and much of the commercially valuable livestock is produced under rainfed small-scale agricultural systems vulnerable to the adverse impacts of climate change (Little et al., 2010; Fratkin, 2014). In addition to climate change agricultural systems in developing countries face other risks such as demand for food by rapidly growing population, changing land tenure systems and ecological degradation (Jones and Thornton, 2009; Rufino et al., 2013).

The current international scientific consensus is that recent global warming conditions indicate a fairly stable long-term trend with natural variability of local climate (Hansen et al., 2012). The notorious variability in local climate conditions and the underlying long-term trend towards global warming makes it difficult for local people to discern climate change. Beliefs and attitudes towards climate change depend on contextual factors including access to climate information and experiential learning. For instance, the large majority of scientists working in disciplines contributing to studies of our climate, accept that climate change is almost certainly being caused by human activities (Hansen et al., 2012). Indigenous people with limited access to climate information are more likely to attribute changing climatic conditions, particularly extreme weather events, to a change in their rituals and cultural practices (Nyanga et al., 2011). Irrespective of the driving forces of perception of climate change, understanding the views of target communities is important to prompt the need to adapt and facilitate support for policy related adaptation decisions.

Perception of climate change among rural communities is driven by multiple forces. Different household and farm factors influence whether and to what extent farmers perceive climate change and its impact on local agriculture (Deressa et al., 2011). Studies conducted in African smallholder farming systems have indicated that the level of formal education attained by farmers influences their ability to perceive climate change and its impact (Maddison, 2007; Mustapha et al., 2012). The age of a subsistence farmer is closely related to their farming experience and accumulated knowledge of the environment including changes in climatic conditions that may go back many decades (Patt and Schröter, 2008; Deressa et al.,

2011; Juana et al., 2013). Households with many members are more likely to engage in non-farm income generating activities because a non-farm income buffers financial losses from farming. These type of householders are less likely to perceive climate change (Ndambiri et al., 2012). Access to support services such as extension services and climate information is purported to increase farmer perception of climate change and its associated risks (Maddison, 2007, ATPS, 2013).

Livestock ownership and herd size in traditional farming systems are two related variables which have been used to represent the level of a farmer's dependence on natural resources such as pasture and water for extensive livestock production (Kemausuor et al., 2011; Belaineh et al., 2013). The availability of these natural resources depends on a combination of resource management strategies and climatic conditions. Different livestock groups have varying degrees of susceptibility to stress conditions such as more frequent and longer periods of drought under a changing climate. For instance, cattle are more vulnerable to feed shortages than small ruminants and have slow post-drought herd regeneration or population recovery from significant losses suggesting a slower biological turnover (Lesnoff et al., 2012). Households with cattle, in the event of drought, carry a potentially diversifiable risk (idiosyncratic risk) as well as the aggregate or covariant risk of drought at a regional scale (Ligon and Schechter, 2003; Lesnoff et al., 2012). However, larger herd size is associated with greater demand for food.

This study uses a psychometric approach to explore how the traditional smallholders have perceived changes to climate over a 20-year period (1992-2012 in the Ethiopian Borana pastoral/agropastoral systems). Psychometrics is one approach commonly applied to the study of perception in different disciplines including climate change (Sjöberg, 2000a). Combined with meteorological evidence from nearby stations, psychometric modelling can be used to generate useful policy-relevant information to better understand the extent of perception of farming communities (Maddison, 2007; Deressa et al., 2011; Belaineh et al., 2013). However, studies in climate change perception using psychometric modelling fail to identify the factors that determine the level at which smallholders perceive climate change and its associated impact. In addition, much more emphasis is given to the mainstream sedentary agricultural systems with less attention to the more marginalized pastoral/agropastoral systems. This study, therefore, examines smallholder perception of climate change and its impact on agriculture in the pastoral/agropastoral systems of Borana vulnerable to climate change. Our results will improve our knowledge of smallholder perception in the Borana traditional system and can be used by decision makers seeking to improve adaptation processes and outcomes.

3.2 Methods

3.2.1 The study area

The study area, Borana pastoral/agropastoral systems lie within the Borana administrative zone (3º36’ and 6º38’N, and 36º43’ and 41º40’E) which is located in southern Ethiopia in the tropics and shares boundary with Northern Kenya in the south (Fig. 8). The Borana administrative zone is broadly divided into two agroecological zones - the high-altitude humid lands to the north and semi-arid lowlands to the south (Tache and Irwin, 2003). The study was carried out in the heartland of the (agro-) pastoral farming systems, in five of the seven semi-arid lowland administrative districts of the Borana Plateau (Yabelo, Dire, Moyale, Miyo, Arero, Teltele and Dugda Dawa).

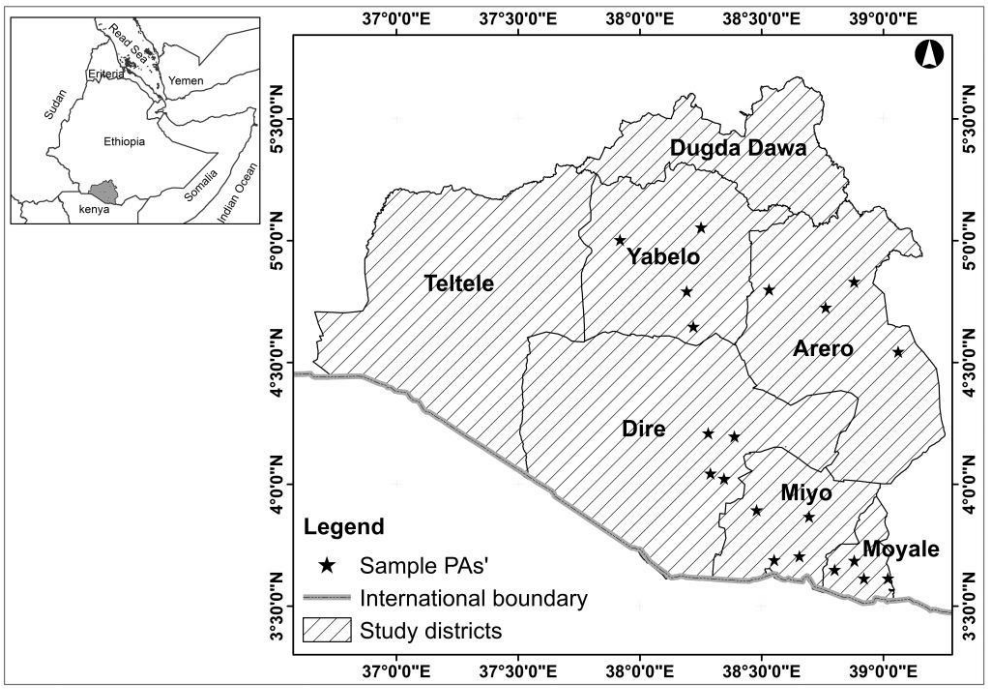

Figure 8. Map of the study area, southern Ethiopia (Note: PA=Pastoralist/agropastoralist association)

The study area has four seasons based on its rainfall variation. These are namely *Bona* (long dry spell from December to February), *Gana* (long rainy period from March to May), *Adolessa* (short dry spell from June to August) and *Hagaya* (short rainy period from September to November). With a bimodal rainfall pattern, as can be seen in F9, the area receives a mean annual rainfall ranging from 350 mm around Wachile town in Arero district to 1,100 mm in Moyale town in Moyale district on the border with Kenya, with an overall

average of about 700 mm (Coppock, 1994). Interannual and interseasonal rainfall variability is uniformly high across locations ranging between 18 and 69 percent of the annual mean (Tache and Irwin, 2003; Angassa and Oba, 2007). Seasonal rainfall amount and distribution is more critical to farmers than annual precipitation as livestock-based rain-fed agriculture depends on seasonal climate (Osbahr et al., 2011). The area on average receives 86 rainy days throughout the year.

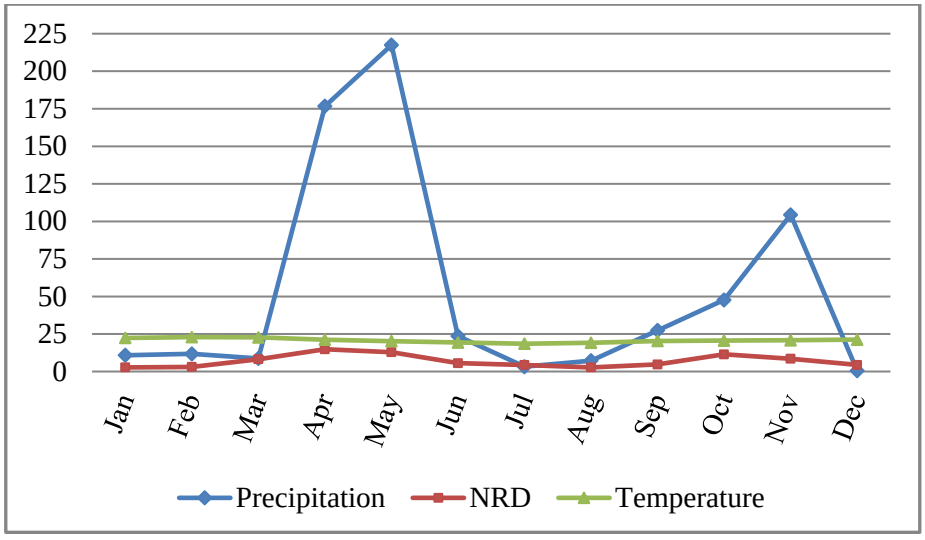

Figure 9. Mean monthly precipitation (mm), number of rainy days (days), and temperature (°C) of the Boran lowlands between 1980 and 2010 *(Data source: NMA, 2012)*

In the study area, the variability of interseasonal and interannual air temperature is much less than that of rainfall. This is consistent with most of agroclimatic zones in sub-Saharan Africa (Coppock, 1994). The long dry season is the warmest season with highest mean maximum and minimum air temperatures with a peak in January. The short dry season is the coldest season with the lowest mean maximum and minimum air temperatures with July the coldest month.

The study selected five sample districts (Arero, Dire, Miyo, Moyale and Yabelo) believed to represent the diverse agroecological and farming system conditions of the study area which present specific contexts for adaptation to climate change (Table 2). Arero district is one of the most drought-prone pastoral areas in the east Borana system. It covers two prominent livelihood zones - the Borana-Guji Cattle Pastoralist where cattle and camel make important livestock species, and Southern Agropastoral livelihood zones where coffee and barley are widely grown while camel rearing , traditional gold and salt mining, and gum production are

additional sources of livelihood (EPaRDA, 2009). Small ruminants and camel production are widely practiced in this district (Table 2).

Dire district is one of the largest districts in the study area and is comprised of three different livelihood zones - Borana-Guji Cattle Pastoralist, Southern Agropastoral and Market Isolated Cattle and Shoat (young pig) Pastoralist (EPaRDA, 2009). The Dire district is known for its high vulnerability to drought, poor market access, chronically food-insecure communities, and predominantly lowland areas where pastoralism is a major production system. With relatively bigger livestock population size, cattle and small ruminants are major animal species in the farm household herd structure.

Miyo district is the southernmost part of the Borana pastoral and agropastoral systems, and shares an international boundary with northern part of Kenya. The district has two major livelihood zones - Borana-Guji Cattle Pastoral with a drought prone pastoral lowland systems, and Southern Agropastoral with pre-dominantly lowland agropastoral systems while crossborder livestock trade and resource based cross-border conflicts with Kenyan counterparts are common phenomena (EPaRDA, 2009). Mid-altitude cultivation of food and cash crops are dominant in Southern Agropastoral zones. Reports indicate that this district suffered the heaviest livestock mortality during the east African drought in 2011 which led to high levels of food insecurity (Personal Communication, 2012).

Moyale district is inhabited by diverse pastoral and agropastoral communities of different ethnic groups including Borana, Guji, Gabra and Gari. The district has two distinct livelihood zones - Moyale Cattle, Camel & Shoat Pastoral livelihood zone, and Moyale Agropastoral, Labor & Cross-Border Trade livelihood zones (ONRS, 2009). The Cattle, Camel & Shoat Pastoral livelihood zone is dominated by dry lowland systems with cattle, camels and shoats and regularly suffers drought-induced food-deficits. The Agropastoral, Labor & Cross-Border Trade livelihood zone is dominated by semi-arid systems whereby opportunistic crop cultivation is practiced, and non-pastoral livelihoods such as off-farm employment and cross-border trade are additional livelihood sources for people in the study area. Due to an increased presence of non-Borana communities such as Somali, Gabra and Garri groups who tend to favour camel and small ruminant production there is a mixed herd structure.

Yabelo district predominantly represents the Borana-Guji Cattle Pastoral livelihood zone. It is the most populous district in the study area (Table 6). The district enjoys good access to livestock market, and livestock sales from cattle and goats (ONRS, 2009) which are the main sources of income for farm households. The district is the most drought-prone and often depends on food aid to supplement food security.

Table 2. Major characteristics of sample districts and pastoral/agropastoral associations (DPDOs, 2011)

Sample PAs by districts	Dominant Production System	Latitude	Longitude	Population (human)	Population (livestock)* Cattle	Sheep/Goats	Camel
Arero(21†)				54,005	174,980	139,719	35,515
Halona	Pastoralism	4º47'59"N	38º31'50"E	3,700	19,780	9,525	1,055
Wachile	Pastoralism	4º32'41"N	39º3'39"E	5,006	15,200	9,470	1,200
Bobela	Agropastoralism	4º49'55"N	38º52'48"E	2,123	2,557	3,500	882
HaroDimtu	Agropastoralism	4º43'33"N	38º45'47"E	4,505	5,700	6,880	800
Dire(16)				82,469	89,398	89,786	4,056
Madhacho	Pastoralism	4º12'36"N	38º16'52"E	5,853	12,605	12,309	1,666
ManSoda	Pastoralism	4º11'49"N	38º23'18"E	4,995	3,657	2,946	141
DidJarsa	Agropastoralism	4°2'42"N	38°17'24"E	1,651	5,000	3,000	10
DidMega	Agropastoralism	4º1'25"N	38º20'44"E	6,442	2,399	1,854	31
Miyo(17)				56,833	61,093	74,762	7,012
Boku	Pastoralism	3°52'2"N	38°41'42"E	10,553	5,852	7,099	602
Melbana	Pastoralism	3°53'39"N	38°28'46"E	5,980	11,472	12,109	645
Dikicha	Agropastoralism	3°42'19"N	38°39'19"E	3,937	3,072	3,360	680
Teso	Agropastoralism	3º41'25"N	38º33'6"E	4,057	1,294	572	216
Moyale(18)				34,842	49,040	11,544	13,305
Bokola	Pastoralism	3°41'15"N	38°52'50"E	6,000	2,461	4,294	720
TileMado	Pastoralism	3º36'52"N	39º1'8"E	9,684	1,569	2,446	400
Dembi	Agropastoralism	3°36'51"N	38°55'134"E	7,467	7,666	8,241	2,800
Tuka	Agropastoralism	3º39'0"N	38 º48'0"E	4,296	1,088	1,508	51
Yabelo(23)				115,371	238,032	138,007	23,326
Harboro	Pastoralism	5º3'18"N	38º15'5"E	3,462	7,680	5,016	548
HarWeyu	Pastoralism	4°29'59"N	38°12'57"E	3,068	11,939	6,547	487
Areri	Agropastoralism	5º0'13"N	37º55'7"E	3,864	8,634	5,632	528
Dharito	Agropastoralism	4º47'32"N	38º11'33"E	4,669	15,371	11,647	594

*Source = District Pastoral Development Offices, 2011; †Number in parenthesis shows the number of PAs within the district.

3.2.2 The study approach

The study focuses on perception of climate change by farm households over a twenty-year period (1992-2012) starting immediately after the publication of the first climate change assessment report and as public awareness started to grow (Melillo et al., 1990). Interviewees

related the year 1992 with the major political incident in the country - fall of the Dergue, a communist regime in Ethiopia which ruled the country from 1974 to 1991. A 20-year timeframe has also been adopted in other studies in Ethiopia (Deressa et al., 2011) and Uganda (Osbahr et al., 2011). In this study, farm household is the unit of analysis. A ‘‘household’’ is defined as a farm family unit consisting of a group of interrelated people living together, sharing the same dwelling house, working on the family farm, making farm-level decisions (including adaptation) and pooling their labour to manage their farm under the prime leadership of the household head (Davies and Bennett, 2007; Solomon et al., 2007).

Interviews were held with the heads of farm households. The choice of the household head as a primary source of information is justified because the household head plays a primary role in the majority of household and farming decisions related to production, marketing, resource allocation and adaptation decisions in traditional farming (Polson and Spencer, 1991; Bryceson, 2002; Solomon et al., 2007). However, typically this method does not necessarily capture the direct opinions of all other members of the household and may to some extent be socially biased particularly with respect to activities not carried out by the head of the household.

3.2.3 Data collection - Methods and tools

This study employed a three-stage sampling design which involved districts, pastoral/agropastoral associations and farm households. Five out of the seven semi-arid lowland administrative districts of the Borana Plateau were systematically selected for the study in the first stage of sampling (Arero, Dire, Miyo, Moyale and Yabelo). Zonal level experts were consulted to ensure that these five districts gave an adequate representation of the different agroclimates and farming systems in the region. In the second stage, four associations (two pastoral and two agropastoral) were randomly selected from each of the five districts. Associations (lowest administration units) within each district were primarily classified by the district Agricultural Development Bureau as either pastoral or agropastoral based on the predominant farming system. i.e. Pastoral if livestock based and agropastoral if livestock rearing and cultivation are integrated.

At the third stage, 24 households from each of the twenty pastoral/agropastoral associations were selected to give a total of 480 sample households. Different transects were drawn from the centre to the border of the association area and farm households lying on different transects were chosen at random until the desired sample size was reached. The sample size selected was sufficient to allow at least a 95% confidence level with 5% precision

or margin of error for the parameter estimate in order to credibly draw conclusions from the data analysis (Cochran, 1977).

The farm household survey was conducted from August to October 2012 in two-steps, a field pre-test and actual survey data collection. The household survey questionnaire was designed following a thorough review of the literature about farmer perception of climate change and its impact on agriculture. The pre-test was conducted in the study area to identify potential problems (e.g. unclear questions) and make sure that the questions and methods were tailored to local circumstances. The questionnaire was then revised based on feedback from the pre-test stage.

The majority of pastoralists and agropastoralists questioned in the testing phase believed they perceived climate change and that the level of awareness was explained in terms of its impact on local agriculture. A question was therefore added and the survey instrument modified to elicit the level of climate change perception through its impact on agriculture using a five-point Likert scale; 1) no perception and thus no perception of impact on agriculture; 2) climate change has been noticeable but has not significantly impacted agriculture; 3) climate change has been noticeable and has impacted agriculture to a certain extent; 4) climate change has been noticeable with a substantial impact on agriculture and 5) climate change has been noticeable and has completely changed the way farming is done.

Enumerators conversant with the local language and customs in the study area were hired to conduct the household interviews during the field research. Before the interviews were carried out, enumerators received field training on the survey instrument and ethical considerations of this research. Each survey questionnaire contained 73 questions and took an average of one hour interview to complete. Research ethics approval was obtained from the Human Research Ethics Committee at the University of Tasmania (Ref# H0012318).

Climate data (monthly rainfall, number of rainy days and monthly temperature), from five meteorological stations covering the study area, were obtained from National Meteorology Agency of Ethiopia. Climatic data were collected for rainfall (amount and number of rainy days), and temperatures for the period prior to (1980-1992), and during (1992-2009) the study period. Available data were then pooled and mean values were computed to evaluate long-term trends in terms of climate variables. However, this study was limited by a lack of sufficient recorded meteorological data for the whole of the study period (1992-2012) as long-term historical weather data was difficult to find due to lack of complete data.

3.2.4 Data analysis - The empirical model

A multinomial logistic regression (MNL) modelling approach was used to explore potential relationships between the different levels of smallholder perception of climate change and its impact on agriculture (the outcome variable) against a set of household and farm attributes (explanatory variables). This modelling makes use of a general logit transformation which is the logarithm of the odds of a particular outcome level relative to the reference level (Stokes et al., 2000). An MNL can be considered as an extension of a logistic regression where the outcome variable only has two different discrete outcomes. The influences of the explanatory variables in the model on the outcome are summarised using odd ratios (OR) which is the ratio of the odds of an outcome level relative to a reference outcome level (no perceived change).

In the analysis, the outcome was the perception level of the climate change and impact of climate change on local agriculture (Stokes et al., 2000; Deressa et al., 2009). As detailed above, levels of perception of climate change were evaluated using a five-point Likert scale as detailed above. The first level of ‘‘no perception’’ of climate change and its impact on agriculture was used as the reference level. These category levels were used to provide an estimate of a respondent’s beliefs and attitudes on a psychometric scale (Sjöberg, 2000b). Following exploratory analysis of the data, the second level ‘noticeable but no significant impact on agriculture’ was omitted in the logistic regression analysis as this level represented only 1% of the total responses. It is important to point out that the direction and nature of the perceived change, i.e. wetter/drier, better/worse was not captured in the outcome variable, and thus responses with the same outcome value may represent different views by the household heads. However, the overwhelming perception is that perceived changes are not favourable to agricultural production as is reflected by widely perceived reduced rainfall and increased temperature conditions.

Based on the literature, a set of variables relevant to the study area were selected as explanatory variables: household size, livestock holding, farm income, non-farm income, education level, age of the household head, type of production system, access to climate information and extension services. We used Proc Surveylogistic, SAS Version 9.2 (SAS Institute, 2000) to run the analysis and to ensure that the results were adjusted for the multi-stage sampling. We conducted an overall test to determine if each variable had a significant effect simultaneously across all multinomial outcome levels and individually for each multinomial outcome level using Wald chi-square tests. The overall test examined whether explanatory variables had any effect on an outcome while the individual tests indicate how the

outcome was affected. For each outcome level, we also present regression coefficients with the corresponding odds ratios.

Overall model fits were assessed using a Generalized Coefficient of Determination (Cox, 1989). Percentages of participants' responses on climatic variables (rainfall and temperature) were computed using descriptive statistics. The Wald chi-square test was used to test the significance of differences between responses, and the responses were summarised as percentages calculated using Proc Surveyfreq, SAS Version 9.2 (SAS Institute, 2000). Seasonal climate data was then computed to examine long-term trends. A regression analysis was then done for the three periods (1981-1992; 1992-2009; 1981-2009) to identify any changes in rainfall and temperature in the study area to validate participants' claim of climate change during the study period and capture potential experiential factors carried forward from the pre-study period. i.e. before 1992.

3.3 Results

3.3.1 Perception of climate change

The majority (96%) of smallholders perceived changes in climatic conditions within the twenty-year period between 1992 and 2012 (Table 3). However, 3% did not perceive any change in climate while the rest (1%) were unsure of whether the climate had changed or not. Among those who perceived a change, 94% and 2% respectively felt there had been a decreasing or increasing pattern, in the amount of both seasonal and annual rainfall, over the twenty-year study period. Disaggregation of perception by age - young adults (23-30), adults (31-60) and elderly persons (>61) indicated that young adults were less likely to perceive changes in climatic variables than their older counterparts (Table 3). Meanwhile, disaggregation of perception by production system (pastoral or agropastoral) revealed significant differences in perception in respect to the direction in which rainfall was changing - both decreasing and increasing (Table 3).

Table 3. Pastoralist/agropastoralists perceptions of existence and direction of changes in overall climate, temperature and rainfall over the past 20 years in the Borana lowlands Ethiopia*

Change category	Overall perception	Perception by age group in years				Perception by production system		
		23-30	31-60	61-91	χ^2 test	Pastoral	Agropastoral	χ^2 test
		% of respondents (n)			*P* value	% of respondents (n)		*P* value
Changes in climate	96(459)	86(37)	97(311)	98(111)	0.00	98(232)	96(227)	0.31
Increase in temperature	66(312)	46(20)	69(221)	63(71)	0.00	68(162)	63(150)	0.41
Decrease in temperature	1(6)	0(0)	1(4)	2(2)	0.00	1(1)	2(5)	0.15
More extremes in temperature	28(132)	37(16)	26(82)	30(34)	0.00	28(67)	27(65)	0.59
Increase in rainfall	2(11)	0(0)	2(6)	4(5)	0.03	1(2)	(9)	0.01
Decrease in rainfall	92(439)	86(37)	94(299)	91(103)	0.03	96(229)	89(210)	0.01

*Perceptions are subdivided by age and type of production system. Values are presented as a percentage of the group followed by number of respondents in brackets (overall N=475)

Beyond changes in overall climate conditions, smallholders indicated varying perceptions towards different climatic elements (Table 3). These included increased day and night temperatures with a considerable proportion of them observing more extreme temperature conditions. In terms of rainfall, smallholders felt there had been a decreasing amount of rainfall and shortening duration of the rainy seasons with the majority (96%) citing a late onset of the rainy season. It appears that pastoralists perceived more overall changes in climate and its attributes than their agropastoral counterparts (Table 3).

Table 4. Pastoralist/agropastoralists perceptions of existence and direction of changes in temperature and rainfall over the past 20 years (1992-2012) in the Borana lowlands, Ethiopia (Overall N=475)

Percentage of responses in each category of change (N=475)						
Which direction do you think temperature and rainfall are changing?						
Climatic variable	Climatic element	Increasing	Decreasing	More extremes	Not sure	χ^2 test *P* value
Temperature (all seasons)	Overall temp	68	1	29	2	0.0001
	Daily temp	95	3	-	2	0.0001
	Nightly temp	57	33	-	10	0.0001
Rainfall (rainy seasons)	Amount	2	92	-	6	0.0001
	Intensity	18	67	-	15	0.0001
How do you see the coming of rains during rainy seasons?						
Rainfall (rainy seasons)	Timing	Early onset	Late onset	More extremes	Not sure	
		1	96	-	3	0.0001
How do you see the length of rainy periods?						
Rainfall (rainy seasons)	Duration	Longer	Shorter	More extremes	Not sure	
		0	97	-	3	0.0001
Which season do you think temperature or rainfall is changing most?						
Changes by season		Long rains	Short dry	Short rains	Long dry	
	Temperature	1	3	94	2	0.0001
	Rainfall	52	0	42	6	0.0001

Study participants who perceived change in climate were concerned about the magnitude and direction of change emphasising that they had the impression of a worsening climate unfavourable for local agriculture (58%), a more unpredictable climate (29%) and more extreme weather events (5%). Only a minority (8%) thought that the climate was becoming more favourable for agricultural production. Asked about the likely future of their livelihoods in ten years, 40% answered that they would be worse off, 27% better-off and 26% found the future difficult to predict due to uncertainty in future climate. Only 7% believed that their livelihoods would remain unchanged. However, all respondents agreed that their future will depend on how well climate favours their rainfed production dominated by livestock enterprise.

3.3.2 Perceived level of climate change and its impact on agriculture

Pastoralists and agropastoralists expressed their perception of climate change in terms of its impact on agriculture to varying degrees (Fig. 10). In total, only 3% did not perceive any change in climate over the study period, 1992 to 2012, while 96% believed the impact of

climate change was noticeable and had varying degrees of impact on agricultural production. All smallholders associated the impact of climate change with reductions in crop/livestock production and considered such reductions as a salient risk posed to their agriculture-dependent livelihoods. It seems that smallholders also try to minimize this risk by obtaining income from non-farm activities, which contribute nearly a third of the total income (Tables 5 and 6).

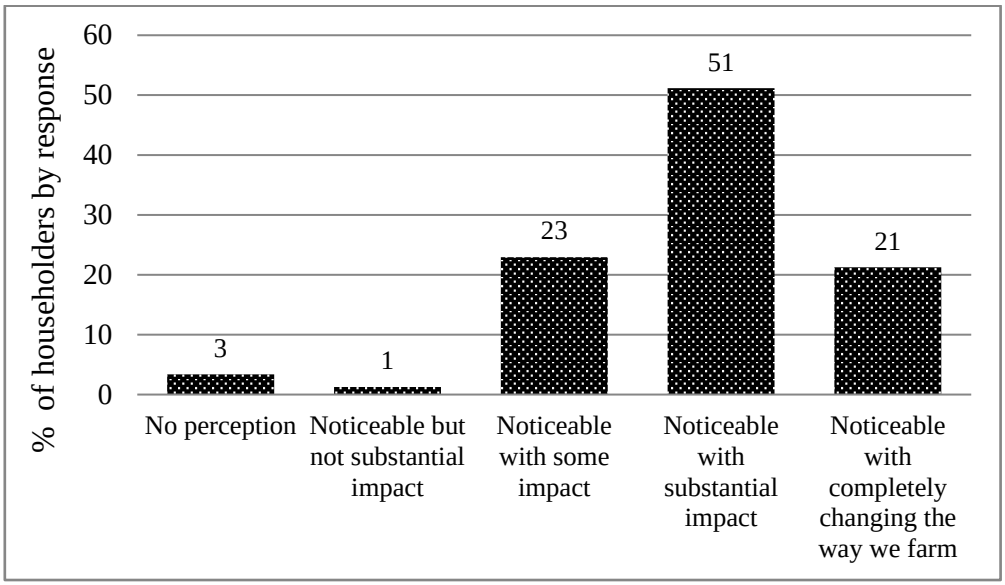

Figure 10. Climate change as perceived in terms of its impact on agriculture over the period 1992-2012 by farm households in the Borana lowlands, Ethiopia

While nearly all of the participants perceived climate change to some extent only 70% had access and were informed by up-to-date climate information, 80% had access to extension service while the average age of the participants was close to 50 years (Tables 3 and 5). While smallholders predominantly depend on subsistence agriculture for their livelihood, income from non-farm activities contributed nearly a third of the total income (Table 4).

Comparison of household livestock ownership and income

Livestock ownership of households in the study area on average is 8.0 TLU with significant statistical differences between households across districts. Households in Yabelo district own the biggest livestock ownership with 10.8 TLU while those in Miyo own the lowest with (6.2 TLU) (Table 5). Highly significant statistical differences were also observed between pastoral and agropastoral households. Pastoral households were found to own bigger herd size (9.8

TLU) than their agropastoral counterparts (6.3 TLU), and own bigger share of cattle in the herd.

Table **5**. Analysis of variance and pairwise mean comparison for household livestock ownership and income

	TLU: Total	Cattle in total ownership, TLU(%)	Farm income ($US)	Non-farm income ($US)
		District		
Arero	7.7[b]	5.0[b](65)	389.0[b]	116.2[b]
Dire	7.7[b]	4.9[b](64)	499.2[a]	208.0[a]
Miyo	6.2[b]	4.1[b](66)	413.0[b]	310.1[a]
Moyale	8.0[b]	4.5[b](56)	478.7[ab]	256.8[a]
Yabelo	10.8[a]	7.2[a](67)	532.0[a]	205.8[ab]
LSD(0.05)	2.7	1.8	102.6	105.4
P-value	0.022	0.013	0.037	0.007
		Production system		
Pastoral	9.8	6.2(63)	500.4	229.5
Agropastoral	6.3	4.0(64)	423.4	209.8
P-value	<0.001	<0.001	0.004	0.100
SEM(±)	0.4	0.30	16.7	17.3
Total(Mean)	8.0	5.1(64)	462.0	219.7

[*]Means within a column followed by same letter are not significantly different from each other at p=0.05; LSD - Least significant difference from Fisher's posthoc test; SEM - Standard error of mean

Mean comparison between different households showed that farm income is significantly different across districts and production systems while non-farm income was significantly different across districts, not by production systems (Table 5). Yabelo which has the highest mean household livestock ownership derived the highest mean income from farming. Miyo with the smallest ownership earned slightly lower, not the least, mean income from farm business and highest from non-farm income (Table 5).

Table 6. Description of variables used to create a logistic regression model for climate change perception of pastoralist/agropastoralists in the Borana lowlands, Ethiopia over the past 20 years (1992-2012)

(a)Outcome variable	Description	Respondents who perceived in % (score values)	Respondents who did not perceive in % (score values)
Level of climate change and its impact on agriculture	0 (no perception) to 4 (Noticeable and completely changing the way we farm)	96 (1-4)	4 (0)
(b)Explanatory variables		Mean	SD
Age	Age of the HH head in years; categorical, 1 if young adult, 2 if adult, 3 if old	49.8	15.3
Education	School attendance; categorical, 1 if no formal education, 2 if primary, and 3 if secondary	1.1	2.6
Household size	Family size of the household in heads; continuous	7.4	2.8
Production system	Production system dummy; 0 if agropastoral and 1 if pastoral	0.5	0.5
Livestock holding	Herd size of the HH in TLU*; continuous	8.0	9.6
Farm income	Annual farm income in USD; continuous	461.9	364.1
Non-farm income	Annual non-farm income in USD; continuous	219.7	375.6
Access to climate information	Access to climate information dummy; 1 if yes otherwise 0	0.7	0.5
Access to extension service	Access to extension service dummy; 1 if yes otherwise 0	0.8	0.4

*Note TLU=Tropical Livestock Unit; HH= Household, $US=18 Ethiopian Birr in 2012

The MNL analysis indicated that effects of age, the level of attained education, livestock holding, access to climate information and access to extension services in determining perception levels were found statistically highly significant ($P<0.01$) (Table 5). Increased odds of perception were associated with increased age (adult vs old), level of education (no formal education vs secondary education), livestock holding, access to climate information and extension services. However, household size, farm and non-farm incomes and production systems had non-significant effects in predicting perception levels. Moreover, the likelihood of the three perception levels against the reference level varied in response to a change in a

unit of an explanatory variable. In summary, household size, farm and non-farm incomes and production systems were not important predictors of perception levels of smallholders.

Table 7. Parameter estimates for the full model and marginal effects from the multinomial logistic regression model of the perceived level of climate change and its impact on agriculture over the last 20 years by farm households in the Borana lowlands.

Explanatory variable	Overall significance of the variable (*P*-value)	Groups	Noticeable and having some effects on agriculture (N=109)		Noticeable and substantially affecting agriculture (N=243)		Noticeable and completely changing the way we farm (N=101)	
			Coefficient (Odds ratio)	*P*-value	Coefficient (Odds ratio)	*P*-value	Coefficient (Odds ratio)	*P*-value
Age	0.000	Age 1 vs 3	-2.130(0.035)	0.000	-0.964(0.167)	0.069	-1.563(0.061)	0.006
		Age 2 vs 3	0.900(0.717)	0.020	0.137(0.502)	0.741	0.326(0.402)	0.391
Education	0.008	Cat 1 vs 3	0.399(0.900)	0.515	0.597(2.299)	0.294	1.002(3.029)	0.091
		Cat 2 vs 3	-0.905(0.244)	0.146	-0.361(0.882)	0.561	-0.875(0.454)	0.173
Household size	0.143	–	0.015(1.015)	0.923	0.065(1.067)	0.643	0.103(1.108)	0.472
Production system	0.566	–	-0.047(0.954)	0.936	-0.289(0.749)	0.595	0.029(1.029)	0.963
Livestock holding	0.004	–	0.436(1.547)	0.001	0.441(1.554)	0.001	0.399(1.492)	0.001
Farm income	0.086	–	-0.0004(1.000)	0.767	-0.0002(1.000)	0.869	-0.0023(0.998)	0.172
Non-farm income	0.159	–	0.0009(1.001)	0.474	0.0016(1.002)	0.160	0.0015(1.001)	0.185
Access to climate information	0.001	–	1.750(5.751)	0.007	1.990(7.313)	0.001	1.351(3.861)	0.038
Access to extension service	0.001	–	1.556(4.742)	0.033	1.786(5.963)	0.002	0.824(2.278)	0.247
Observations used					465			

Note: reference level = no perception of climate change; pseudo-R^2 = 0.223

Different levels of perception were found to show different odds for a unit change in various explanatory variables (Table 7). The odds of perception at all levels increased significantly as livestock holding increased by an additional tropical livestock unit. Access to support services also improved the likelihood of perception among smallholders. Results from the interview revealed that 70% of the smallholders had access to up-to-date climate information while 80% had access to extension service. Smallholder access to climate information was significantly associated with increased odds of perception at all levels as compared to those who did not perceive (Table 7). In addition, advisory support through extension services appeared to significantly improve the odds of perception at the lower and middle level, and at the highest level, albeit non-significantly.

3.3.3 Perceived causes of climate change

When asked about the possible primary causes of climate change, no one mentioned the role of greenhouse gases in driving climate change. Smallholders suggested that the major drivers of climate change were supernatural forces (45%), natural (physical) process (33%) and deforestation due to human action (16%). A small number (6%) of respondents were unsure or could not give an explanation of the causes for climate change.

3.3.4 Climate data for 1992-2009 and 1981-1992

Climate data indicated significant increases in temperature during the 1992-2009 period (Table 8). There was an increasing trend in rainfall amount observed during the study period across the two rainy seasons though the one in the long rains season was not statistically significant. Simultaneously, the number of rainy days significantly decreased during the long rains season while the change was not significant for the short rains season of the 1992-2009 period. In contrast to trends in the study period, the preceding period 1981-1992 was characterized by a sharp decline in rainfall amount across the two rainy seasons which might have carried an experiential legacy among participants. The number of rainy days and temperature did not however show any significant trends during same preceding period.

Table 8. Changes in the moving averages of observed climatic variables between 1981 to 2009 in the Borana pastoral/agropastoral systems, Ethiopia

Season	Duration	Rainfall		Number of rainy days		Air temperature	
		Slope(mm/yr) (R^2)	P-value	Slope(days/yr) (R^2)	P-value	Slope (^oC/yr) (R^2)	P-value
Long rains	1981-1992	-26.97 (0.65)	0.001	-1.46 (0.28)	0.092	-0.07 (0.13)	0.241
	1992-2009	+1.97 (0.10)	0.190	-0.43 (0.37)	0.009	+0.02 (0.32)	0.013
	1981-2009	-9.10 (0.50)	0.000	-0.64 (0.45)	0.000	+0.01 (0.01)	0.732
Short rains	1981-1992	-8.83 (0.63)	0.002	+0.03 (0.00)	0.909	+0.17 (0.19)	0.154
	1992-2009	+4.76 (0.25)	0.034	+0.05 (0.01)	0.758	+0.04 (0.32)	0.014
	1981-2009	+0.73 (0.02)	0.469	+0.13 (0.12)	0.072	+0.05 (0.17)	0.024

3.4 Discussion

Household farm characteristics of the study area

Herd size and its composition is an important indicator for understanding livestock systems in the study area. Results have shown that livestock ownership between farm households across districts have shown significant differences. While Yabello has shown the biggest average household herd size, the lowest livestock ownership figure in Miyo may be associated with high mortality as a result of the 2011 severe east African drought for which the district suffered the biggest loss as the survey was conducted a year after the crisis (Personal communication, 2012). In terms of production systems, pastoral households owned bigger herd size (9.8 TLU) as compared to their agropastoral counterparts (6.3 TLU) which justifies the latter integrate cultivation as an additional economic activity to improve household income.

In terms of herd composition, livestock ownership is dominated by cattle across districts and production systems whereby cattle contributed on average 64% of the livestock ownership (Table 5). As compared to other districts, cattle contributed the least share of households' livestock ownership in Moyale district as the district has diverse non-Borana community who has lesser affinity for cattle as compared to Borana community and tend to have mixed herd that comprises camel and goats. Though wealth is often considered the primary driving factor for the reliance of households on different types of livestock, other factors such as culture, the changing market and environmental conditions also contribute to determine the composition.

Though agropastoralists who integrate livestock with cultivation are expected to earn more from diversified income sources, they were found to earn significantly lower income than

those pastoralists who depend on livestock. This suggests the insignificant contribution of cultivation to household income in Borana. In support of this, a study by Tache and Oba (2010) reported that there is little evidence that cultivation played any more than a supplementary role in Borana systems where crop yield is significantly lower as compared to productivity in sedentary agricultural systems in the rest of the country. Interestingly, those households in Miyo where livestock ownership and farm income are the lowest made the biggest non-farm income. The relatively higher non-farm income in Miyo can be attributed to cross-border trade and employment opportunities in nearby towns in neighbouring Kenya.

3.4.1 Perception of climate change

The large majority of smallholders in the study area believed that they had experienced climate change during the study period in terms of increased temperature and declined rainfall. Smallholders indicated that they perceived changes in temperature and rainfall, expressed mainly in terms of patterns in weather experienced; higher temperatures, below normal rainfalls, late onset and shorter rainy seasons, and higher frequency and intensity of extreme weather events. Similar expressions of awareness by rural communities about climate change have been reported in various studies conducted over the same two decades as this study in Ethiopia (Belaineh et al., 2013), Nigeria (Tambo and Abdoulaye, 2013) and Chile (Roco et al., 2014). However, except in the case of study from Chile, no attempt was made in these studies to relate perceptions of climate change to meteorological evidence.

During the 20-year period covered in the survey in this study (1992-2012), the limited meteorological evidence suggests that climatic change in terms of seasonal temperature did occur which is consistent with perceived change in temperature among participants. Trend analysis has shown that statistically significant increases in temperature were observed during the study period. A significant increase in rainfall amount during the short rainy season was observed while no established trend can be seen for the long rainy season.

The participants' claim that rainfall amount decreased during the short rainy season is not in agreement with meteorological evidence and is contrary to observations at least in statistical terms. Again the claim that rainfall amount decreased during the long rainy season cannot be substantiated with meteorological evidence as there is no established trend. Thus there is a significant mismatch between the meteorological evidence and strength of opinion in claiming decreasing rainfall amount. This overwhelmingly perceived declining trend in rainfall amount could be attributed to the decreasing number of rainy days during the long rainy season. Or the increase in temperature may have resulted in higher evapotranspiration

and greater moisture stress. There might also be other attributes (e.g. onset and secession of the rainy season, length of growing period, etc.) of the actual climate that has not been captured in this dataset, which potentially contributed to shape smallholder perception of climate change for this area where livelihoods are climate dependent.

Climate change is a difficult and complex phenomenon to easily and accurately detect and track based on personal experience as it is a slow and gradual modification of average climate conditions (Weber, 2010). This suggests personal observation and evaluation of the climate does not necessarily lead to accurate results that can be substantiated with meteorological evidences. In addition, behavioural factors such as expectations of change (or stability) also affect the ability of people to detect trends in uncertain phenomenon such as climate. For example, rare climatic events such as severe drought have smaller probability of occurrence but have a much larger impact on livelihoods when they occur that affects learning and decision making based on experience more volatile (Lowe, 2006; Weber, 2010). In other words, fear reactions can be instigated when perceived threat is more than the ability to cope with the said threat. This response may lead to emotionally charged decisions than a well thought analytically and objectively processed decisions that require cognitive effort. Despite the inconsistency between perceived changes and meteorological evidence, participants across the study area present a consistent story of changes in climate.

Although this data should be treated with caution, the apparent minimal changes in climate during the study period mean a valid area-wide perception that climate change had occurred over the 20-year period. However during the two decades of the study (1992-2012) the rainfall was less, there were fewer rainy days and higher temperatures in comparison to the preceding decade (1980-1992) (Fig. 11). The anomaly indices in Figure 11 illustrate that average rainfall amount during the study period is lower than the preceding decade. This indicates that if the respondents were comparing the two phases (1980/1992 to 1992/2012) their perceptions were clearly based on reality and experience. Thus in spite of clear and explicit instructions only to consider the past 20 years, it is highly likely that perceptions were modified by experiential factors especially perception of change from an earlier period, possibly not surprising given that the average age of the smallholders was close to 50 years.

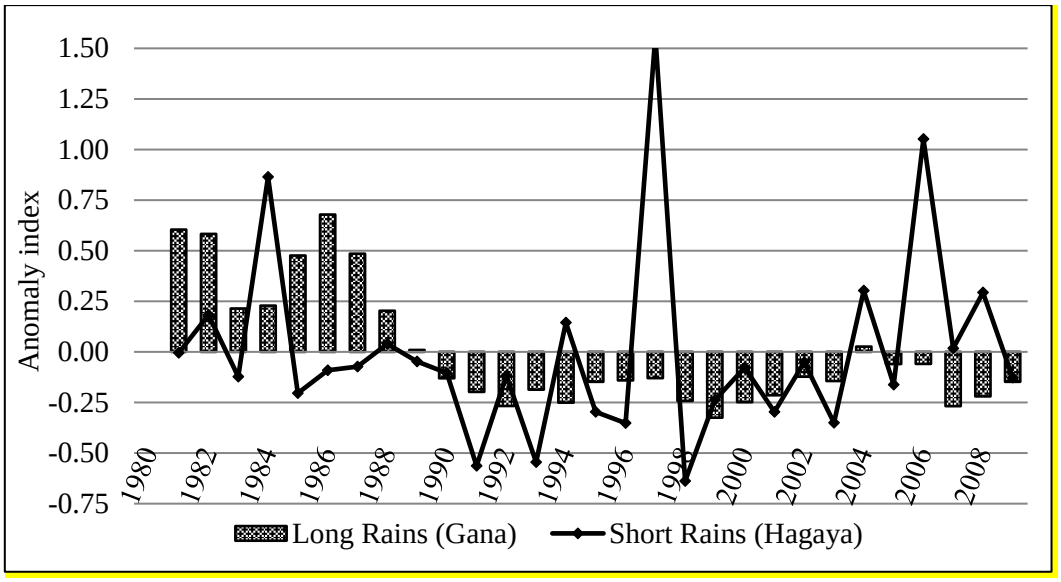

Figure 11. Rainfall anomaly indices for the two rainy seasons in the Borana lowlands between 1981 and 2009 (Data source: NMA, 2012)

Perception may be modified by other factors such as extreme events of climate variability or complex interactions between climate and non-climate forces that have noticeable impacts. These factors could be simplistically perceived to be the result of climate change but decoupling them is difficult. Judgement under uncertainty, as in climate, often rests on simplified heuristics and biases than well-founded rationality which involves extensive algorithmic processing (Gilovich et al., 2002). In particular, the recent personal experience of worsening circumstances under periodic and severe drought (e.g. in 2008 and 2011) may drive a belief that climate had significantly changed during the study period. Whitmarsh (2008) argued for a human tendency to readily trust ‘‘their interpretation of an experience’’ as reality and as such causal attribution may not be well-managed (Ahn et al., 1995). However, this perception remains relevant to climate change related policy and decision-making as it prompts smallholders for climate change action which could be mitigation or adaptation. The key issue here is that perceiving climate change in the wrong way may lead to incorrect decisions related to adaptation which may result in costly mistakes. This suggests the need to complement experiential learning with cognitive ideas requiring analytic processing and solid evidence.

Inconsistency between actual and perceived changes has far-reaching practical implications for climate change responses such as adaptation in terms of public policy and decision making (Patt and Schröter, 2008; Hansen et al., 2012). Decisions based on unfounded information do not guarantee best responses in terms of adaptation and potentially

incur a transitional cost due to misperceptions (Kolstad et al., 1999; Maddison, 2007). Transitional cost is defined as ‘‘…the difference between the maximum value of net revenues per unit area following perfect adaptation and the net revenues actually experienced by farmers given that their expectations of (and therefore response to) how the climate change will lag behind what it actually does (Maddison, 2007).’’

For example, most vulnerability analysis and adaptation tasks based on assessing the impact of climate change on agricultural production compare effects of the baseline ‘no climate change’ and pre-defined climate change scenarios. However, the fact that future climate carries uncertainty means current decisions based on expectations of future climate may be inefficient and would appear to be of only limited importance. Wilby and Dessai (2010) and IPCC (2013) indicated that the scenario-led climate risk assessment for adaptation planning to anticipated climate change has little practical importance for adaptation decisions as compared to the vulnerability-led method. This is true as predictive climate and impact models carry uncertainty for which farmers tend to be reluctant to invest their meagre resources.

The lesser perception of climate change by younger vs older householders (86% vs 98%; Table 3) may reflect less exposure to climate stimuli and reduced experience in terms of dealing with changing farm conditions and activities. This lesser perception by younger householders agrees with findings of similar studies conducted in farming systems from semi-arid Africa (Deressa et al., 2011; Silvestri et al., 2012; Teka et al., 2013). However, the discrepancy between young households noticing climate change and the lack of continuous and complete meteorological evidence for the study period might be attributed to an influence from their older counterparts citing that climate was better in the previous decades.

Findings suggest that pastoralists were more pessimistic than optimistic about the future of their farming livelihoods. A similar study by Yu et al. (2013) reported that majority of the public discern that climate change does harm to local residents and society. The Borana smallholders’ experience of climate during the study period (1992-2012) was characterized by rainfall conditions consistently below those in the preceding decade threatening their climate-sensitive livelihoods. Under limited access to climate information, perception of the magnitude and direction of climate change has often been explained in terms of beneficial or adverse changes in the livelihood of rural communities (Gandure et al., 2013). Vulnerability to drought appears to be the major driving factor of perception of climate change and salient risk to local agriculture and livelihoods.

3.4.2 Perceived level of climate change and its impact on agriculture

Our results suggested that various household and farm attributes affected the perception of rural smallholders about climate change and its impact on local agriculture. The farm income of larger herders has been observed to be more sensitive to adverse climate change (Seo and Mendelson, 2007). This sensitivity was also observed in this study. An additional TLU on average increased the odds of feeling limited effects of climate change by a factor of 1.520 as compared to those farm households who did not perceive any changes (Table 7). Livestock keepers with a cattle dominated herd structure, in particular, find it difficult to cope up with feed shortage during drought years (Lesnoff et al., 2012).

This study suggested that educational activities - years of school, access to climate information and extension services strongly influenced and increased the perception of climate change and its impact on local agriculture. A higher level of education resulted in a greater awareness of climate change as a real issue of immediate concern, which increased the likelihood that changes in farming practices were attributed to the impact of climate change. However, the odds of increasing likelihood of the perception levels were not statistically significant which might be attributed to the observation that more educated ones are the younger ones.

Smallholders who have access to climate information are more likely to be able to interpret and apply this information to their lives making them aware of local climate change or variability which becomes crystallised into a perception of climate change. The impact of education and access to weather information on perception (i.e. a higher level of education associated with a greater probability of use of climate information and perception of climate change) has been commonly reported for smallholder farmers across African farming systems (Mustapha et al., 2012; Ndambiri et al., 2012; Amdu et al., 2013). Access to weather information has shown to result in significant benefits in Kenya, Ghana and Zimbabwe by increasing the awareness of climate change in terms of more informed adaptive decisions and improved technology uptake among smallholder farmers (Kalungu et al., 2013; Mapfumo et al., 2013).

Both farm and non-farm incomes did significantly modify smallholders' perceived level of climate change and its impact on local agriculture. Results indicated that farm households in the study area on average earn nearly a third (32%) of their annual income from non-farm sources which suggests income diversification. Dependency for income is therefore associated with external contingencies influencing off-farm income generating activities or employment and does not drive a perception of climate change. Off-farm income will also

increase diversification opportunities and therefore buffer any income losses and adverse effects of climatic events such as drought.

Livestock holding was significantly associated with climate change perception (Table 7). This may be driven by the reliance of livestock on pasture and water, which are both climate-sensitive resources. Access to advisory support through extension services also improved the perception of farming communities. This can be attributed to the advisory support and training programs that assist smallholders in taking climate change as problem and context which need to adapt to. In addition, production system did not affect smallholder perception of climate change which might be attributed to the shared high level of vulnerability of rainfed farms to climatic shocks. In general, the variables including age, education, livestock holding, access to climate information and extension appeared to be the most important factors influencing perception of local communities and ensuring their participation in decision-making at different scales which can be translated into useful policy information.

3.4.3 Perception of causes of climate change

Like many traditional communities in sub-Saharan Africa, this study showed that a significant proportion of Borana smallholders (45%) consider that humanity is cursed and supernatural forces are the primary cause of climate change. Disobedience and unfaithfulness to God's rules, failure to glorify him and divergence from the age-old Borana tradition have led to divine punishment, especially drought events. This spiritual perspective is widespread in Africa (Patt and Schröter, 2008; Gandure et al., 2013; Tambo and Abdoulaye, 2013). Similarly, Teka et al. (2013) reported farmers in Benin partly attributed climate variation to failure in observance of traditional customs and endogenous laws by the indigenous community.

Others (33%) freely acknowledged that climate is changing but did not associate climate change with human activities except for deforestation. While traditional smallholder farmers would not be exposed to information about greenhouse gas emissions, they most likely would have directly experienced the aggravating effects of indiscriminate tree cutting for firewood and charcoal production on desertification (Nyanga et al., 2011). A small proportion of interviewees (6%) was unsure or had no idea about the drivers of climate change perhaps reflecting the complex and intangible nature of climate change.

3.5 Conclusion

Smallholders in the Borana pastoral/agropastoral systems overwhelmingly had a perception of a changing climate between 1992 and 2012, despite limited meteorological evidence of significant change during that period. There were climate attributes whereby perceived changes were not consistent with meteorological evidence which may lead to wrong climate change responses such as adaptation. It is highly likely that this perception was modified by other factors such as personal experiences especially perception of more rainfall in the 1980s and the severe droughts experienced recently including in 2008 and 2011. The later extreme events may explain anxiety and fear instigated overwhelming pessimism by farmers about the future of their livelihoods and their view that climate change will increasingly and negatively impact agriculture. We conclude that extreme events (e.g. drought) in this regard played a crucial role in influencing participants' attitude about climate change and its impact.

While the perception of some aspects of climate change by smallholders did not seem to be related to the direction to which climate variables actually change, it was related to access to climate information. Smallholders showed varying levels of perception and attitudes towards climate change and its impact, and these responses were most likely influenced by non-climatic forces such as pervasive social, economic and political changes. This result is possibly not unexpected given the smallholder's sensitivity to climate variation, which may explain the confounding effect of non-climatic factors also called ''intervening conditions'' on perception levels as decoupling the effect of climate from that of non-climate factors is often difficult.

Pastoral and agropastoral communities have not been actively engaged in the national policy landscape and this has been partly attributed to a biased approach towards modern agriculture and negative attitude towards pastoralism often seen as a waning lifestyle (Davies and Bennett, 2007). This attitude has resulted in a poor understanding of development needs and priorities for these farming communities living at the edge increasingly constrained by climate change. Our study showed that pastoralists, agropastoralists and their communities are clearly aware of climate change. Collecting this information will play a critical role in engaging resource-constrained farmers so that they can become active participants in adaptation and policy making. Moreover, our findings highlight the need for enhancing the awareness of the risks associated with climate change so that farmers have realistic expectations and are better prepared not only for the potential negative impacts but also for taking advantages of any opportunities climate change offers.

Acknowledgements

We would like to acknowledge the Borana rural communities for their time in responding to our questions during farm household interviews and group discussions. We are grateful to Belay Simane for his advisory support and enumerators who took part in the household interview. We extend our thanks to the National Meteorology Agency of Ethiopia for their support in providing historical weather data, and the University of Tasmania for financial support.

Compliance with Ethical Standards

Research ethics approval was obtained from the University's Research Ethics Committee and informed consent was also obtained from research participants.

Chapter 4: Household options for, and barriers to climate change adaptation in pastoral/agropastoral systems of Borana, southern Ethiopia

Abstract

Support to smallholders to assist them in adapting to climate change needs to be relevant and informed by improved understanding of the local options for and barriers to adaptation. This study employed a mixed methods research approach to systematically examine elements of adaptation in the pastoral/agropastoral systems of Borana in south Ethiopia, a region vulnerable to the vagaries of climate. In particular, a combination of the Pressure-State-Response (PSR) and Pelling's typological frameworks was used to analyse adaptation to climatic stimuli and its effects. We conducted farm household surveys, focus group discussions and expert consultations in the region in 2012. Results of the study showed that pastoralists/agropastoralists and their communities adopted various adaptive measures primarily through adjusting farming practices and diversifying into non-pastoral livelihoods. Farm households and communities mostly relied on indigenous methods of adaptation for which local knowledge and resources including indigenous institutions played a pivotal role. Moreover, the smallholders pursued resilience measures (mainly intended to avoid major system disruptions) and transitional adaptation (resulting in incremental changes) rather than transformational approaches that ensure long-term adaptation goals. Shortage of financial resources, inadequate technical assistance and limited policy support were found to be major barriers limiting and shaping adaptive capacity. Our overall assessment is that adaptive capacity of Borana pastoral/agropastoral systems is low and vulnerability remains high. Therefore, adaptation pathways that promote long-term adaptation, address key barriers and build on local resources are urgently required to reduce vulnerability and improve livelihoods in these fragile agricultural systems.

4.1 Introduction

Climate change poses critical challenges to agriculture and food systems in the developing world including Africa. The fact that the majority of Africans depend on agriculture for their livelihood implies a vital link between climate and development in the region (Bisaro et al., 2010; Baudoin, 2013). Climate change can impede the ability to achieve development whilst development can reduce vulnerability to climate change. The effect of climate change on agricultural production is well acknowledged and adaptation to climate change has become an increasingly relevant policy agenda (Schlenker and Lobell, 2010; Mueller et al., 2011). In

view of the necessity to adapt, humanity is facing a range of choices structured around resilience (stability or maintaining the status quo), transition (incremental social change and practicing existing rights leading to incremental change) and transformation (new rights claims and changes in political regimes leading to radical change) (Pelling, 2011). Though differences exist in adaptation pathways, the approaches have a common goal of primarily addressing human vulnerability to climate change and associated risk while evaluation of outcomes depend on context and viewpoint of individual actors.

Agriculture in Ethiopia is comprised of primarily traditional smallholder farming systems predominantly under rainfed production. The increasing vulnerability of these systems has been attributed to various bio-physical and socio-political factors including climate change (Deressa et al., 2011), land tenure systems (Gebre-Selassie and Bekele, 2011) and market conditions (Davies and Bennett, 2007) which have consistently hindered agricultural development in Ethiopia (Mideksa, 2010; Gebre-Selassie and Bekele, 2011; Gebrehiwot and Veen, 2013). Recurrent extreme climate events mainly droughts have been especially major contributors to this high level of vulnerability and chronic food insecurity (Araya and Stroosnijder, 2011; Conway and Schipper, 2011). Responses to climatic irregularities by resource poor smallholders with limited adaptive capacity in Ethiopia are largely spontaneous and do little to promote livelihoods and facilitate agricultural development (Belay et al., 2005). The responses also strive to achieve short to midterm adaptation goals.

The Borana society is an ethnic group of egalitarian pastoralist/agropastoralists communities inhabiting the arid and semi-arid areas of southern Ethiopia and northern Kenya. Livestock are fundamental economic and cultural assets, and herd size is traditionally an important indicator of wealth and social status. The Borana traditionally follow an indigenous religious belief system (*Waqefatta*) while local institutions play important roles in everyday life including managing and regulating access to common property resources, and shaping human-environment interaction. Agriculture and resource governance have evolved for centuries and indigenous institutions and cultural practices are geared to deal with a highly variable rainfall climate at inter-seasonal, annual and decadal scales (Tache and Sjaastad, 2010). Debela et al. (2015) identified that the current levels of climatic variability and change are overwhelmingly perceived by the local farming communities primarily due to increasing frequency and intensity of recurrent droughts, and associated ecological effects and human impacts. The highly variable climate means that adaptation options may need to be specific at a local level (van Ginkel et al., 2013). Both socioeconomic and ecological vulnerability are significant and felt among the farming communities.

Substantial work has been done in the global north to understand barriers and limits to adaptation and ways to diagnose and ameliorate barriers (Moser and Ekstrom, 2010). On the other hand, persistent 'adaptation deficit' in the developing world led to focused research on barriers to adaptation. A central finding of this research is that local institutions and culture are often slow to change, and the status quo tends to prevail in the face of calls to make significant departures from current practices and paradigms in order to protect and improve livelihoods. In 2011, the Ethiopian government initiated a Climate Resilience and Green Economy strategy with adaptation as an essential element of the policy response to climate change problems (FDRE, 2011). The major criticism of the strategy is that it overlooks the importance of local actions which are at the heart of agricultural adaptation, and rarely acknowledges significant differences in local needs and priorities across diverse farming systems including sedentary, pastoral and agropastoral systems. Marginalization of pastoralism has been a common policy failure in Ethiopia and many other countries in Africa (Benjaminsen and Ba, 2009; Muller-Mahn et al., 2010).

In this paper, we examine adaptation options and major barriers to adapt to climate stimuli and its effects in the traditional Borana farming systems. Adaptation can be directed to climate variability (including extreme conditions) and climate change (long-term mean or norms). We acknowledge that for purposes of adaptation, climate variability (including its extremes) is an integral part of climate change (along with shifts in mean conditions), and responses to these stimuli are interrelated. We use a combination of Pressure-State-Response (PSR) and Pelling's theoretical frameworks to assess options and barriers to adaptation. Developing a sound theoretical and practical understanding of adaptation options and barriers within their specific context in the adaptation framework will inform decision-making to adaptation planning at both regional and local scales. This novel approach will provide a basis for promoting successful adaptation tailored to the needs of the Borana rural communities.

4.2 Methods

4.2.1 The study area

The study area, the Borana pastoral/agropastoral systems, is part of the Borana administrative zone situated in Oromiya Regional State, southern Ethiopia. The study targeted lowland districts of the Borana Plateau which constitute the heartland of the Borana pastoral and agropastoral systems (Coppock, 1994) known to be frequently hit by climatic stresses and its effects with significant socioeconomic and ecological vulnerability. Geographically, the study

area lies in the tropics region, and is located between 37 and 41 degrees E, and 3 and 7 degrees N.

4.2.2 The theoretical framework

The Pressure-State-Response (PSR) framework provides a widely used and intuitively accessible framework (Dong et al., 2011) for developing detailed accounts of farming communities response to climate stimuli and its effects through adaptation. The framework enables us to examine and enhance our understanding of how i) climatic stress puts pressure on pastoral/agropastoral systems, and ii) smallholders respond to protect local agriculture and livelihoods. We also use the typology of Pelling's (2011) framework to classify and analyse adaptation options adopted by various actors in the study area. We triangulate between qualitative and quantitative social research methods and data to validate results. Results are discussed in relation to the framework and address the central questions of this paper: what were the adaptation options adopted and the major barriers that limited the adaptive capacity and shaped routes of adaptation in the Borana pastoral/agropastoral systems?

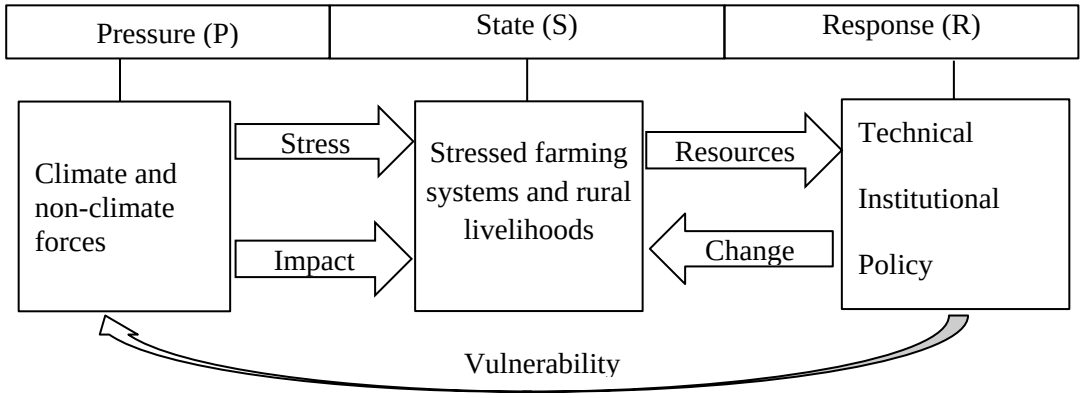

Figure 12. A conceptual diagram of the modified Pressure-State-Response framework used to analyse adaptation in the Borana pastoral/agropastoral systems

As shown in figure 12, adaptation can be considered as a response to current or anticipated pressures from stressors on an exposure unit (plot, field, farm, region, national and international etc.) which results in a given state of that unit such as farming system and livelihoods they support. *Stressors* can be considered as any climatic or non-climatic negative cause that brings economic, social or environmental pressure, harm or distress (McDowell and Hess, 2012) but in this study refer only to those associated with climate variability and change. The *impact* of climatic stress is often adverse although beneficial opportunities exist

and positive impacts are possible. *Options* in our case are any adaptive measures adopted as a response to stressors and impact associated with climate conditions. *State* refers to the status or condition of the exposure or adaptation unit as a result of exposure to climatic or non-climatic conditions and stressors. These include enabling or restricting environments in which response (adaptation) is considered to pressures from climatic and non-climatic forces. A *response* is any adaptation action or measure undertaken to contain or overcome the impacts from climate stimuli that affect the state of the adaptation unit.

Pelling (2011) provided a useful typology of adaptation based on its different attributes - goals, phasing, degree of collaboration and origin of measures. Pelling (2011) argued that adaptation goals can be considered as; 1) 'Resilience' approaches which strive to maintain systemic function and the *status quo* or bring marginal change(s) in a changing climate by which the ''normal'' state of the adaptation unit continues to function in the context of constraining factors, without explicitly challenging these; 2) 'Transitional' adaptation measures, which push against the *status quo* by suggesting incremental social reform and the exercising of existing rights as a result of experienced or predicted change and therefore transitional change aims to bring incremental change in a system of concern; and 3) 'Transformational' approaches acknowledge that to enable the scale of change required, then it is necessary to structure or establish completely new ways of doing things, robust institutions, practices, processes and forms of governance to bring 'radical change'. This type of adaptation therefore envisions reconfiguring the structure of development to enable adaptation. In addition, Pelling (2011) states that adaptation options are 1) 'Proactive' (or anticipatory) when they take place before a climate risk manifests itself into a hazard, or 2) 'Reactive' when adaptation takes place after a climatic event. Adaptation options are either 1) 'individual' when decisions to adapt involve individual actors, and 2) 'collective' when decisions involve more than one actor.

4.2.3 Research approach - methods and tools

In today's research world, studies are increasingly complex, interdisciplinary and dynamic. This is challenging to the ability of purist quantitative (objectivist) and qualitative (constructivist) approaches to best address complex research questions that span disciplinary domains (Johnson and Onwuegbuzie, 2004). The traditional purist approaches, qualitative and quantitative, thus may not be able to provide the pragmatic advantage mixed methods offer.

The mixed-method approach allows methodological pluralism or eclectism that often results in superior research as compared to the traditional purist or mono-method research

approach (Johnson and Onwuegbuzie, 2004; Driscoll et al., 2007). The compatibilist or mixed method approach allows researchers to combine and tailor methods to better answer the research question as well as provide an opportunity to facilitate communication and inform research (Driscoll et al., 2007). We, therefore, believe this mixed-method approach is a more holistic way of fitting together the different rural communities' insights and experiences obtained through the qualitative and quantitative methods.

Quantitative data collection involved a random sampling across five districts and twenty pastoral/agropastoral associations of Borana. The five sample districts were systematically selected from the ten districts of the Borana lowlands, which represent the diverse agroclimatic and farm heterogeneity within the region. For each district, two pastoral and two agropastoral associations were selected in stratified random sampling method to represent the two production systems. Individual association (stratum) was represented by 24 farm households selected in a simple random sampling method. A total of 480 farm household heads representing their respective households were interviewed. The survey questionnaire included structured and semi-structured components covering questions on options and barriers to adaptation. Household interviews were administered by trained enumerators with close field supervision. Finally, the data were managed and analysed using an SPSS (Statistical Package for Social Scientists) program (IBM Corp, 2012).

Qualitative data were collected from 20 focus group discussions comprising of 6-10 participants who had long-term experience in farming at each of the 4 pastoral associations in a district. These focus groups reviewed and reflected on major adaptation options and barriers in the context of overall farming system dynamics and settings. In addition, we had informal consultations with local agricultural development experts working at the district and zonal levels in the study area. The data obtained through focus group discussions and expert consultations were then summarized and described qualitatively to complement the quantitative data. Triangulating these methods was carried out to ensure the validity of results and improvement in the explanation of options and barriers to adaptation. The classification assumes that, in the extreme, options are different in terms of their adaptation goals, timing of adaptation in relation to a risk to manifest itself into a hazard (phasing), degree of collaboration among actors and its immediate impact on the adaptation unit. 4.3 Results

4.3.1 Adaptation options

The various adaptation responses or options identified in the household interviews and focus group discussions in the study area to pressures from climatic stresses are classified below using the typology of Pelling's (2011) framework (Table 9).

Table 9. Classification of adaptation options identified by the Borana pastoralists and agropastoralists in interviews and focus group discussions

Adaptation strategy	Adaptation vision	Phasing	Degree of collaboration	Function	Origin or Source
Livestock supplementary feeding	Resilience	Proactive/ Reactive	Individual	Pools or avoids risk across space/time	Indigenous/ Introduced
Herd mobility to remote areas	Resilience	Reactive	Individual/ Collective	Pools or avoids risks across space/time	Indigenous
Herd diversification	Transitional	Proactive	Individual	Reduces risks across livelihood sources	Indigenous
Sell out livestock	Resilience/ Transitional	Reactive	Individual	Reduces or avoids risks across space/time	Indigenous
Cultivation of crops	Transitional	Proactive	Individual	Reduces risks across livelihood sources	Indigenous
Water development and/or maintenance	Resilience/ Transitional	Reactive	Collective	Pools or reduces risks across space/time	Indigenous/ Introduced
Get support from social safety-net	Resilience	Reactive	Collective	Pools risk across households	Indigenous
Take-part in Productive Safety Net Program	Resilience	Reactive	Individual/ Collective	Reduces risk across livelihood	Introduced
Off-farm employment	Resilience/ Transitional	Reactive	Individual	Reduces or avoids risks across livelihood sources	Indigenous
Receive food aid from NGOs or government	Resilience	Reactive	Individual/ Collective	Reduces risks across households	Introduced

*Individual refers to individual farm households

The adaptation options identified by the Borana pastoralists and agropastoralists are further detailed as:

Supplementary feeding - This consists of the storage and/or purchase, and use of hay for supplementary livestock feeding. Focus group participants stated that adoption of this measure began in recent decades when population pressure and rangeland degradation was believed to limit herd mobility and produce a grazing-induced stress on rangelands. Farm households collect and store native grasses and legumes in protected homestead areas in anticipation of drought, or purchase it during peak feed shortage as a result of drought. Households decide on whether to employ supplementary feed for livestock as an adaptive measure to adopt. Traditionally, fodder has been used for feeding weak and lactating animals but its use for the overall herd has been a recently introduced measure suggested by extension services.

Off-farm employment - This includes any non-farm income generating activities for the individual and farm households to overcome climate-induced food insecurity and financial stresses. Participants stressed that off-farm employment often involved travel to nearby towns or a neighbouring country Kenya following drought events. Common forms of non-farm employment included casual labour, petty trade, traditional mining, gum collection, fuelwood collection and charcoal production. Participants stressed that the decisions to undertake non-farm employment by the individual or household primarily were driven by the need to secure an income for food insecure households affected by climatic stresses. However, they also acknowledged that farm families may transition to non-farm employment and this partly represented a tendency to shift into non-pastoral livelihoods in response to changing climatic conditions.

Herd mobility to remote areas - This option involves the movement of satellite *forra* herds into remote fall-back regions when seasonal rainfall is anticipated or noticed to fail in their local area. The seasonal movement between wet and dry season grazing areas is a routine transhumance practice in pastoralism in Ethiopia and neighbouring Kenya. This takes place during extreme weather conditions involving travel to usually remote areas to overcome feed shortage due to climatic stresses. Focus group participants stated that the travel could take weeks or months to distant marginal areas across neighbouring communities and countries. Herd mobility has been practiced for generations and occasionally result in resource-based conflicts (due to competing demands among users) and overexploitation.

Livestock sell out and destocking - Participants generally tend to sell livestock during the peak drought period primarily to avoid loss of animals from die-offs. Participants believed that selling livestock provided relief from massive animal deaths but underlined a preference to maintain a large herd as long as possible to absorb shocks and enjoy the cultural prestige associated with owning livestock. Participants identified this financial gain was commonly used to buy food for the household and feed for the remaining herd while the notion of destocking to reduce the grazing pressure on communal rangelands was rarely practiced. This adaptation measure has been used for a long-time and households (in consultation with clan leaders) traditionally decide on sales of animals. Participants stressed that they would be reluctant to destock before climatic stress and would rather wait until forced to sell them during or after drought events when prices for animals substantially decline due to drought-induced market oversupply.

Productive Safety Net Programme (PSNP) - The PSNP is a social protection programme that engages chronically food-insecure rural households for cash or on a food-for-work basis on intensive local development activities including water point maintenance, bush clearing and rural road clearing. The PSNP is often jointly funded by government and donor agencies such as the World Bank and is introduced after peak drought periods. This program aims to assist disadvantaged households in coping with drought-induced chronic food insecurity while simultaneously supporting local development.

Cultivation of crops - This is a locally-driven expanding adaptive measure adopted to deal with future climate risk and uncertainty through diversification of income and spreading risk across enterprises. Participants mentioned that in recent decades farm households have increasingly moved into annexing plots of land from traditionally managed communal rangelands for cultivation of food crops which in many cases has resulted in transition of livelihoods from pastoralism to agropastoralism. Opportunistic cultivation involves privatization of communal grazing lands which is consistent with state laws but contravenes and undermines the traditional tenure system which encourages collective land use.

Water development - Participants stated water development and maintenance was labour intensive and involved the maintenance of existing livestock water points (e.g. shallow and deep wells, ponds, small earth dams, rock catchments, and water pumps) and development of new ones to provide additional access to livestock and local communities in response to

climate stresses. Improved access and utilization of water resources were made possible by collective actions.

Herd diversification - Herd diversification denotes a locally introduced change in household livestock composition marking a transition from a previously cattle or cattle-dominated herd structure that was susceptible to drought to a mixed livestock composition including drought tolerant animals such as camels and small ruminants. In addition to lower susceptibility to droughts, browsers like goats and camels enabled pastoralists to take advantage of the availability of alternate food sources such as shrubs and trees in the face of deteriorating quality of rangelands. The mixing of herd was primarily employed to deal with risk and uncertainty in anticipation of climatic stresses.

Social safety net - The local social safety-net is a three-tiered traditional social insurance system whereby Borana households who lose cattle in droughts receive a livelihood recovery support from other fellow clan members. Participants stated that this age-old traditional community support is provided in the form of cattle which takes three different forms: - *busa gonofa*, *ames* and *rebaray*. *Busa gonofa* involves restocking through donation of cows from fellow clan members to help rebuild the herd, *ames* is when a Borana family gives a lactating cow on short-term loan, and *rebaray* involves the donation of a cow by a family as a permanent gift to support livelihood recovery.

Receiving food aid - Participants recognised food aid as an emergency post-shock response strategy whereby households in urgent need for food get access to food supplies from state or non-state sources to cope up with climate-induced food shortage. Focus group participants stated that this often takes place immediately after drought events leading to chronic level of household food insecurity prompting government and donor responses.

The most widely used adaptive measures identified by households were by percentage: supplementary livestock feeding (29%), off-farm employment (16%), herd mobility (16%), livestock sales (13%), productive safety-net programme (7%), crop cultivation (6%), water development (5%), herd diversification (3%), social safety-net (2%) and receiving food aid (1%) (Fig. 13).

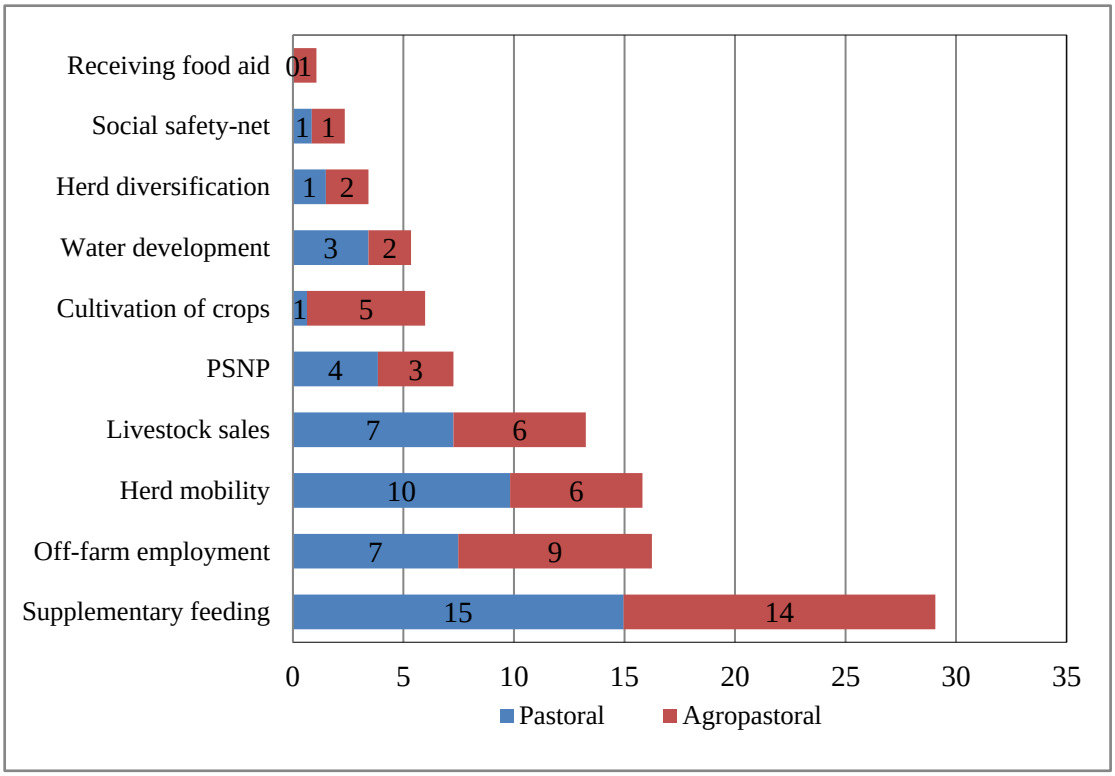

Figure 13. Percentage of pastoral (n=240) and agropastoral (n=240) household interviewees identifying adaptive measures adopted across production systems

4.3.2 Barriers to adaptation

The large majority (87%) of the pastoralists/agropastoralists felt that there were barriers impeding adaptation to climate change in the study area. In contrast, the remaining 13% suggested that there were no barriers they knew impeding adaptation. These barriers or limiting factors correspond to the State component of the PSR theoretical framework where both enabling and restrictive environments operate to determine routes for adaptation. The barriers identified as important by household heads were:

Limited finance - Poor access to finance and credit constrain adoption of any adaptation options which require capital, and thus impact most on substantial adjustment in production and livelihood systems. Focus group participants stated that lack of capital and access to credit services often limit adoption of capital-intensive adaptation options like introducing camel into the household herd which is much more expensive than cattle (e.g. camel can often cost three times more than cattle). Participants stressed that frequent and severe climate stresses depleted resources that could potentially be used for current and future adaptation.

Limited knowledge - Participants stated that limited understanding of climate change, improved technology and technical skill sets severely challenged their adaptive capacity to ensure improved adaptation processes and desired outcomes. Limited local level know-how and expertise constrained adoption of knowledge-intensive adaptation measures which often are introduced.

Limited weather/climate information - Participants identified a lack of up-to-date weather forecast and climate information relevant to local agricultural production (including rainfall and temperature) as a barrier constraining adaptation. Focus group participants stated that due to limited access to locally relevant science-laden accurate climate information, they have to rely on traditional forecast methods. Households and communities therefore often depended on traditional methods of forecast which increasingly has become irrelevant due to the increasingly unpredictable weather.

Limited labour - Shortage of labour represents insufficient household workforce required to implement labour-intensive farm and field-level adaptive measures to adapt to changes in climatic conditions. Study participants mentioned limited household labour constrained adoption of labour-intensive adaptation measures such as improving the productivity of grazing land through bush clearing.

Limited land - Shortage of land was identified as a barrier that limited access to family or household managed agricultural land that could be used in adaptation. For example cultivation and private pasture that could help income diversification and maintain feed reserves.

Limited government support - Inadequate government assistance to farm households and communities was recognised as a barrier to overcoming the negative impacts of climate change. The support could be in the form of technical, financial or policy backing to facilitate successful adaptation. Participants emphasized that government support rarely understood local needs and priorities in terms of adaptation and overall development goals.

Limited access to market - Limited access to fair markets to sell farm produce including livestock and grains as well as limited access to input markets to buy inputs necessary to improve production and support successful adaptation were identified as barriers to adaptation.

Participants indicated that low prices for livestock discouraged them from destocking livestock during peak drought periods.

Limited access to irrigation - Lack of access to readily available water resources for full or supplemental irrigation was identified as barrier for reducing reliance on rainfall for production. Participants stated that limited access to water resources hindered the prospects of adopting irrigation and reducing dependency on rainfall as a long-term adaptive strategy.

The three most mentioned barriers were 1) limited access to finance (57%), 2) limited scientific and technical knowledge (45%) and 3) limited climate information (44%). Each of these was identified three times more frequently than the next most common concerns identified by the traditional farming community (Fig. 14).

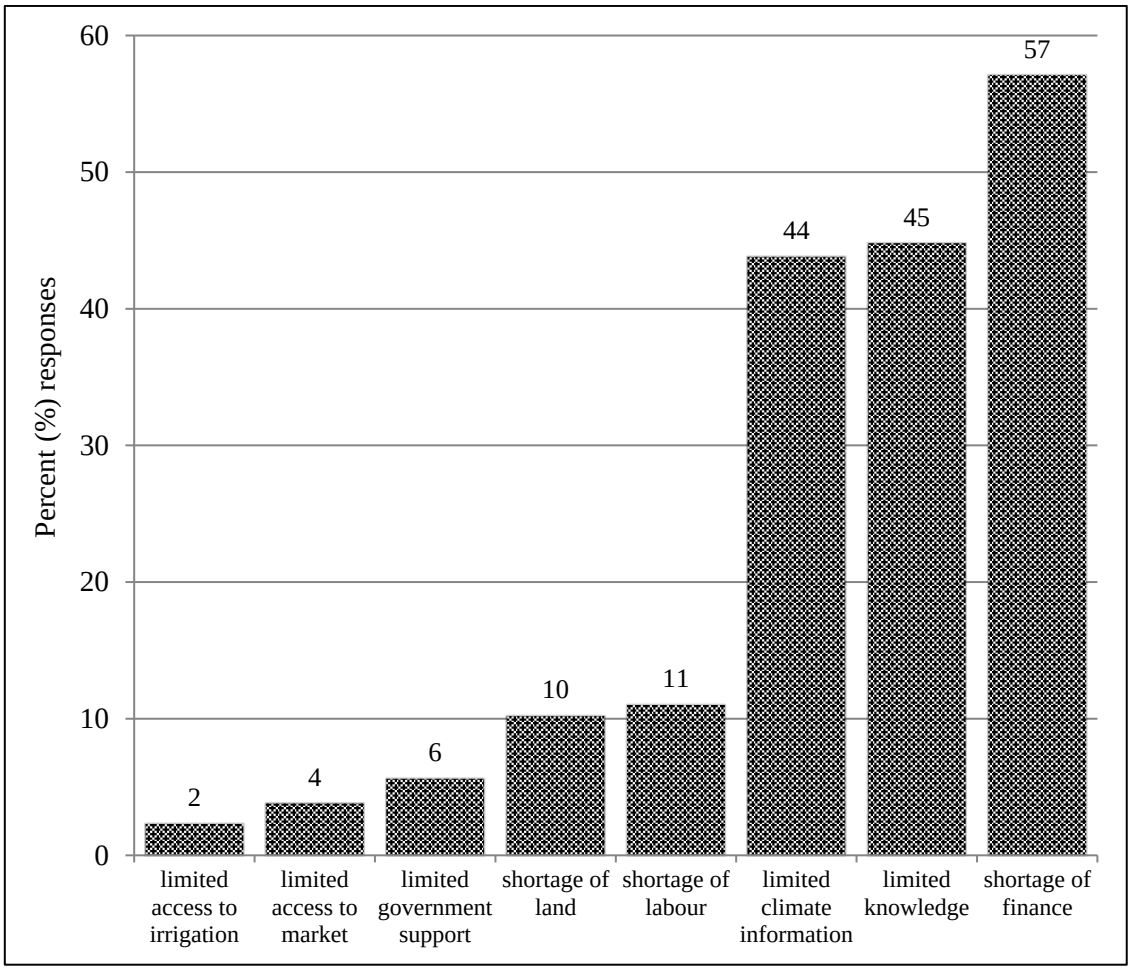

Figure 14. Frequency of adaptation barriers identified as important by household heads (n=480)

4.4 Discussion

4.4.1 Adaptation options

Smallholders in this study adapted to climate change through measures that can be broadly grouped into - adjusting farming practices and shifting into non-pastoral livelihoods. The measures embrace short to medium term adaptation to climatic variability and perceived long-term changes in climate. The majority of the measures taken were intended to address current climate perturbations rather than addressing anticipated future climate conditions. Few of those adaptive measures, such as herd diversification and integrating cultivation into livestock keeping, seems aimed at addressing expected changes in future climate conditions perceived to result in water stress both in crop and animal agriculture due to widely perceived declining rainfall. Whereas, adaptation options were mostly reactive rather than anticipatory indicating that adaptation in the study area was a response to pressures indicating that the PSR framework is a suitable theoretical framework for analysing adaptation to climate change and its effects in the study area as it emphasises the response (options) component.

A considerable number of pastoralists and agropastoralists who had previously specialized in livestock keeping are now integrating the cultivation of crops with livestock keeping which suggests transitioning into a more diversified livelihood system. While the traditional transhumance lifestyle is favoured and has not disappeared (Galvin, 2009; Tache and Oba, 2010; Tsegaye et al., 2013), this diversification of livelihoods in response to changing climatic and socioeconomic conditions is becoming a common strategy in many pastoral systems in east Africa including Ethiopia (Desta and Coppock, 2004; Homann et al., 2008b; Tache and Oba, 2010). While adaptation measures target addressing the vulnerability to climate change and its effect, options such as herd diversification were also suggested to improve declining household incomes.

Adaptation options in our study reflected a strong preference for pathways that lead to resilience (coping) and transitional adaptation resulting in incremental change within the context of existing institutional and cultural arrangements. As in other studies, pastoralists and agropastoralists strived to avoid system disruption, minimize expected losses and ensure the continuation of the preferred transhumance lifestyle, traditional pastoralism (Tsegaye et al., 2013). This approach highlights the emphasis given to buffering against the negative impacts of climate shocks and maintaining stability rather than making major, non-marginal changes that will significantly address vulnerability and ensure livelihood improvement. The resilience approach to adaptation to climate change undermines the chance for long-term adaptation, and prevent changes that can potentially improve livelihoods and ensure sustainable development

(Berman et al., 2012). Arguably, there is a wider understanding that coupled adaptation and development goals can be achieved through transformational adaptation. The high costs and risks (economic, social, cultural, etc.) associated with transformative actions nonetheless make it difficult for resource-poor farmers to pursue transformational adaptation that claims 'radical change' in existing systems (Rickards and Howden, 2012). Enhancing adaptive capacity would be an important precondition for substantially addressing vulnerability and ensuring development.

The type of strategies as defined by resilience goals predominantly attempt to maintain the *status quo* and allow unsustainable management systems to endure. These strategies, often short-term, autonomous and *ad hoc,* paid attention to reducing loss of assets but gave less emphasis to supporting and promoting livelihoods that could help reduce vulnerability in the longer term. For example, livestock supplementary feeding and herd mobility are two popular strategies used to support livestock through the dry spells - and are strategies which are critical to survival (Homann et al., 2008b). The strategies however do little in terms of reducing the long-term human and ecological vulnerability to anticipated climate changes.

While still incremental in nature, adaptation options that have transitional goals go beyond an attempt to maintain functional persistence and involve moderate social change and reforms and restructuring of activities and livelihood systems (Pelling, 2011). In our study, incorporating herd diversification, the cultivation of crops and off-farm employment into existing economic activities are good examples of medium to long-term pathways of incremental adaptation with transitional goals. Both activities contribute to creating a more diversified household income but without abruptly changing rural livelihood structures. In this regard, as adaptation in the Borana involves resilience and transitional goals, there is little or no evidence that adaptation significantly contributed to livelihood improvement and long-term development. Adaptation in the study area focuses on buffering or reducing losses from climate change shocks instead of adapting to future climate and reducing vulnerability. This suggests the need to promote long-term adaptation that sustainably addresses the root causes of vulnerability and promote socioeconomic development.

Driven by climate and non-climate intervening factors, the Borana farming systems experienced a shift into agropastoralism, adopting integrated crop-livestock systems. The gradual metamorphosis of pastoralism to agropastoralism seems a necessary corollary of in the Borana as it has been for dryland east Africa (Galvin, 2009; Rufino et al., 2013). For instance, Afar pastoral systems in Northeast Ethiopia are under intense pressure to make a shift to agropastoralism (Tsegaye et al., 2013). Those with this traditional lifestyle and in

marginal ecosystems are aware of its risk and uncertainty (Debela et al., 2015), and are going through the inevitable economic and social change processes. However, the motivation for the choice of each adaptation measure remains complex and it is likely that non-climatic forces or 'intervening factors' are at play with climate stimuli. There is no evidence that a system-wide shift into agropastoralism is the desired change from the perspective of the Borana community.

Role of indigenous knowledge

In our study, the Borana pastoralists and agropastoralists appear to make little use of external inputs to improve resilience and productivity in the face of current and anticipated changes in climate and its effects. Local adaptation options draw primarily on indigenous knowledge and locally available resources. Herd mobility, the social safety-net, the cultivation of crops and the sale of livestock were identified as good examples of indigenous ways of adaptation suggesting that adaptation is largely a local practice. In particular, herd mobility is a complex adaptation option. It relies on the traditional laws of the Borana indigenous institutions to regulate access to communal water and range resources (Homann, 2004) and is typical of other regions in east Africa e.g. smallholders in Kenya also rely on indigenous knowledge and practice to pursue local level adaptation (Speranza et al., 2010). Indigenous institutions are profoundly important in supporting local level adaptation and overall development even in the face of conflicting interests and fragile relationships between state and indigenous institutions when it comes to land tenure systems (Watson (2003). The next empirical chapter will examine the role of indigenous institutions in adaptation to climate change and its effects in Borana.

Adaptation outcomes

We understand that many of the adopted measures resulted in positive outcomes or conditions of varying degrees in short or long-terms, and some fail to reduce vulnerability to result in 'maladaptation'. While adaptation is intended to reduce or avoid vulnerability various studies suggest that certain measures may increase vulnerability across time and/or space (Adger et al., 2005; Barnett and O'Neill, 2010; Eriksen et al., 2011). The different values and interests of individual actors involved in adaptation strongly influence the evaluation of adaptation pathways and subsequent outcomes (Eriksen et al., 2011; Pelling, 2011).

We found that the common practice of moving herds to remote areas, was a good example of an adaptive action that leads to maladaptation in the medium to long-term. Participants

stated that feed resources are critically limited during severe droughts and lead to a high concentration of mobile herds around a given remote fall-back region. This overexploitation of resources may be an adaptation option in the very short-term but will undoubtedly increase vulnerability to climatic stress in the future. Opportunistic cultivation can undermine adaptation because cultivation reduces grazing land available and crop yields might be insignificant when rainfall is relatively low in order to offset losses from the livestock sector (Desta and Coppock, 2004). In general, while adaptation efforts are meant to ensure positive expected outcomes, such decisions must also consider any potential undesired impacts.

Livelihood impacts due to recurrent and severe droughts witnessed in the recent decades suggest the Borana may not be able to keep moving with the *status quo*. Adaptation approaches that envisage resilience and transitional approaches do not seem to sufficiently address the vulnerability challenge that uncertain climate poses and adaptation strategies of a more transformational nature are required. In the face of recurrent droughts which reduced recovery periods, there is little evidence that adaptation efforts have significantly contributed to vulnerability reduction and livelihood improvement. There is little or no evidence that the Borana community has become food self-sufficient as a result of incorporating cultivation into their farming (Tache and Oba, 2010). Food insecurity is pervasive and the household resources base is diminishing reducing the capacity to adapt to future changes in climate.

Transformational adaptive strategies could be those that are truly new to a particular region or resource system, adopted at a much larger scale and that transform places and shift locations (Kates et al., 2012). Transitioning from rainfed onto efficient irrigation systems that reduce or avoid dependency on the natural rainfall could be a good example. Transformational adaptation in agriculture however poses potential great gains as well as great risks that need to be carefully considered in decision making (Rickards and Howden, 2012). Despite the demanding nature of transformational adaptation, it provides an impetus for planned or intentional adaptation that meaningfully promotes livelihood improvement and sustainable development.

4.4.2 Barriers to adaptation

This study indicated that, despite a clear recognition by the Borana pastoralists and agropastoralists of an urgent need to adapt to climate variability and change, there are significant barriers to successful adaptation. When these barriers are combined with other socio-economic and political constraining factors, there is limited adaptive capacity. In situations such as this, smallholders are often forced to engage in short or medium term

resilience and transitional approaches to adaptation rather than transformative approaches (Kates et al., 2012). Without a doubt the identified barriers impeded the process of adaptation.

Our study indicates that among the different groups of barriers, institutional and financial barriers play an important role in prescribing routes for adaptation and limit adaptive capacity. Institutional factors, in particular, have been shown to play important roles in prescribing options and shaping adaptation at different levels (Jones and Boyd, 2011; Upton, 2012). For example, competing interactions between institutions may weaken local institutional capacity for adaptation. Homann et al. (2008a) noted that the involvement of state and non-state agencies through a top-down interventionist approach was seen as interfering rather than helpful to the local adaptation process in Borana. This was partly attributed to development policies and strategies that were biased towards "modern sedentary agriculture" which viewed pastoralism as an outmoded lifestyle (Homann et al., 2008b; Tsegaye et al., 2013). A significant component of this bias was towards promoting externally driven approaches rather than endogenous development approaches favoured by the Borana pastoral and agropastoral communities.

Weak financial capacity and poor access to markets for locally produced agricultural products (i.e. livestock and livestock products) greatly limited the ability of the Borana smallholders to adopt capital-intensive adaptation options. For example, limited financial resources constrained the farmer’s ability to purchase camels as a way of diversifying herd structure and shifting to more drought tolerant livestock. Previous studies also indicate that a lack of adequate resources (including finance and knowledge) is key to limiting adaptive capacity to an incremental survival mode (Tribbia and Moser, 2008; Moser and Ekstrom, 2010).

The impact of adaptation barriers as described in the study has been further compounded by a shrinking recovery period due to the increasing frequency of droughts. Between the 1980s and 2000s, drought frequency in Borana used to be approximately every six to eight years (Riché et al., 2009; Huho et al., 2011). However, over the past two decades, drought frequency has increased to almost once every three years, greatly reducing the recovery time between two consecutive drought events. The cumulative effect has been an erosion of the resource base which has seriously undermined the ability of households and communities to adapt to future climate.

4.5 Conclusion

Smallholders of the Borana farming systems will continue to depend on rainfed agriculture for their livelihood, at least in the foreseeable future. This dependency means that smallholders will be required to successfully deal with climate-induced stress to reduce vulnerability in the context of many other internal and external pressures. In this study, we examined options and barriers to adaptation in the pastoral/agropastoral systems of the Borana using a PSR framework and adaptation typology by Pelling (2011). This study also indicated that it is possible to use the typologies of Pelling (2011) to categorise adaptation and these categorisations are valuable for understanding the nature of the issues and adaptive responses in the study area.

The Borana widely recognise the ongoing climate-induced stresses and their effect that robust adaptation is a necessity and not an option. The overwhelming feeling is that current and anticipated changes in climatic conditions are not in favour of agricultural production and local livelihoods. The smallholders respond to climatic stresses through adjusting farming practices and shifting into non-pastoral livelihoods that help them reduce or avoid system disruptions that negatively impact local agriculture and livelihoods in the longer term. Indigenous knowledge and practices play a substantial role in enabling them to adapt as external support for local level adaptation is limited. Adaptive measures applied in one location could increase vulnerability in another location leading to maladaptation.

Since the focus of adaptation is on reducing losses, there is little or no indication that adaptation to climate change by farm households and communities in the study area significantly reduced vulnerability or improved livelihoods. Short-term coping measures taken to maintain the stability of existing livelihood systems can unintentionally affect the future adaptive capacity of a system and undermine long-term climate change adaptation. This suggests the need for a strategic shift from short-term coping to longer term adaptation measures aimed at reducing vulnerability and improving livelihoods. There is also no evidence that socioeconomic and ecological changes made through smallholder adaptation are those wanted by the community. For instance, a shift from pastoralism into agropastoralism is not desired by many as traditional pastoralism is a favoured lifestyle by the majority.

There were complex barriers that constrained adaptation. Interacting barriers prescribed available routes for adaptation, limited adaptive capacity and shaped adaptation outcomes. There was substantial tension between state and traditional institutions underpinning adaptation options involving communal resource governance. For instance, villagization policies presented an unenforceable, top-down regulatory interventionist approach to change

land tenure systems whereby local resource governance indigenous institutions become irrelevant due to state laws. Interventions in this area need to be conducted carefully to avoid subsuming traditional practices and institutions with simplistic regulatory controls of people and stock movement. Potentially useful avenues would be to build local adaptive capacity through integrating indigenous institutions into national policies and programs about long-term vulnerability reduction and livelihood improvement.

Acknowledgement

We are grateful to those Borana farm households and communities who devoted their precious time to answer questions during the farm household interview and focus group discussions in the field. Our special thanks also go to the experts and district level officials who assisted us in facilitating the fieldwork, and enumerators for their assistance in conducting farm household interviews during the fieldwork.

Chapter 5: Role of indigenous rural institutions in adaptation to climate change in Borana pastoral/agropastoral systems, south Ethiopia

Abstract

Institutions, particularly indigenous ones, have been shown to play a crucial role in enabling adaptation to climate change through shaping collective action, enhancing adaptive capacity and framing adaptation responses among rural communities. However, their role has often been ignored or overlooked by misguided policies and programs. Using an adaptation, institutions and livelihoods (AIL) framework, this study identifies and examines the key roles that indigenous institutions play in climate change adaptation in the Borana pastoral/agropastoral systems of Ethiopia. Data were collected from ten key informants through face-to-face interviews. These interviewees represented ten pastoral and agropastoral associations or villages across 5 districts of the study area. Data were qualitatively processed using NVivo software and analysed using a thematic analysis approach. The analysis revealed that Borana indigenous institutions play an important role in three key adaptation areas: 1) regulating access to common-pool resources required for adaptation, 2) supporting post-shock livelihood recovery, and 3) providing traditional climate early warning systems which reflect a tacit and vast knowledge of the environment even if they are expressed as deistic manifestations. Indigenous institutions provided resilient and untapped resources to enhance successful adaptation to climate change among the rural communities in Borana. However, the role of the Borana indigenous institutions is diminishing, in part due to persistent misguided top-down interventionist approaches by state and non-state development actors. Future adaptation efforts should consider bottom-up endogenous approaches that integrate indigenous institutions in the decision-making process to empower communities act in their own collective interest. Local resources should be exploited to complement external support and to ensure improved adaptation outcomes.

5.1 Introduction

Institutions are human-created formal and informal structures or mechanisms that shape expectations, interactions and behaviour of individuals and societies (Ostrom, 1990; Agrawal and Perrin, 2009). Dovers and Hezri (2010) stated that institutions reflect the underlying rules or patterns of behaviour in a society. Institutions are a means to hold society together, give it a sense of purpose and enable it to take collective action on matters of common interest such as

economic development and adaptation to climate change (O'Riordan and Jordan, 1999). Institutions can be broadly characterised as either formal or informal, local, regional or global internal or external. Institutions can be classified into different sectors - public (local governments and their administrative units), civic (cooperatives and membership organizations) or private (not-for-profit organizations like NGOs, and profit-oriented private businesses) (Uphoff and Buck, 2006). Institutions are fluid and dynamic, reflecting changes of ideas and balances of power (Watson, 2003; Dovers and Hezri, 2010); they are not unchanging entities as is widely and erroneously perceived (Ostrom, 1990; Dovers and Hezri, 2010; Ostrom and Basurto, 2010). But are constantly evolving entities in step with changing needs and priorities of societies.

Institutions have been recognised as central to collective action on short- and long-term action on climate change, enabling or constraining adaptation whether at the local or global scale. Institutions help define climate change both as a problem and a context, through devices such as scientific knowledge, culturally defined interpretation and politically tolerable adaptation policies (O'Riordan and Jordan, 1999). More importantly, they enable communities to act in their own collective interest. Rural institutions enhanced adaptive capacity and increased livelihood security in rural Kenya (Washington-Ottombre and Pijanowski, 2013). The author argued that institutions reduced vulnerability by enhancing collective action and reducing vulnerability. Moreover, institutions define actions that are prohibited, required or permitted in a specific context.

Indigenous institutions are institutions presenting distinct opportunities for actors in unique socioeconomic, cultural, political and environmental settings. Indigenous institutions are a customised set of power structures which encompass customary rules, indigenous knowledge and traditional practices that influence the behaviour of individuals and the community (Watson, 2003; Washington-Ottombre and Pijanowski, 2013). They provide different actors with resources, knowledge, legitimacy, identity, and a sense of meaning (O'Riordan and Jordan, 1999; Berkhout, 2012). They play pivotal roles in managing common-pool resources by regulating access and control over them as well as arbitrating contested claims concerning the overuse of these resources although the problem of "free-riders" will always remain innate to collective resource management and may result in overexploitation (Wang et al., 2013). Indigenous institutions also shape collective action, structure vulnerability, influence adaptive capacity and frame adaptation to climate change. Berman et al. (2012) argue that collective decision-making as facilitated by indigenous institutions plays a vital role in creating

transformational changes that improve adaptive capacity and are a vital source of untapped resources.

Certain indigenous practices which are closely adapted to a local micro-environment and previously discounted as "archaic" are now considered as sustainable and provide practices that may reduce the level of risk (Speranza et al., 2010). Smallholder farmers in developing countries may lack the necessary technical and financial support to adopt different or less traditional technologies (Eakin, 2005) and so must continue to rely on their traditional knowledge and practices to deal with challenges including climate change (Watson, 2003; Nyong et al., 2007). Along with the physical and social capitals, local institutions are known to contribute to enhancing adaptive capacity and shaping individuals', social groups' and communities' response to climatic shocks and stressors.

Indigenous institutions have interlinkages with both formal and informal institutions across different scales. Indigenous institutions interact and interrelate with internal (e.g. local government structures) and external counterparts (e.g. non-state actors such as NGOs) (Dovers and Hezri, 2010; Berkhout, 2012). They represent local values and address local needs and priorities much better than external counterparts. There have been studies whereby lack of trust in the effectiveness of state institutions has been found to be an important factor affecting the relevance and influence of state institutions in local adaptation and development. For example, Baudoin (2013) reported that state institutions in southern Benin were not as capable of supporting adaptive capacity at the local level as indigenous institutions which enjoy significant levels of trust among communities.

There is a growing interest in incorporating existing indigenous institutions into adaptation processes as a pathway for improving the adaptive capacity of the agricultural sector in Ethiopia. Past studies on the institutional aspects of climate change adaptation have mainly focused on national level policies while overlooking the importance of indigenous institutions in supporting local adaptation practices (Agrawal and Perrin, 2009). Indigenous institutions in Ethiopia may have the potential to mobilize resources and facilitate collective actions and could play both enabling and constraining roles of local adaptation (Kamara et al., 2004; Homann et al., 2008a). In this regard, there exists a significant body of research that explores adaptation responses in which institutions are important actors. However empirical studies on how institutions bring about collective action to enable adaptation are limited.

For this study, we will use a modified version of the adaptation, institutions and livelihood (AIL) framework proposed by Agrawal and Perrin (2009) in order to analyse institutional adaptation to climate change in the Borana farming systems (Fig. 15). Agrawal and Perrin

(2008) underline that institutions influence adaptation and livelihood among rural households and communities in three important ways - 1) structuring the distribution of climate risk impacts, 2) constituting and organizing the incentive structures, and 3) mediating external interventions into local contexts. The framework will help pinpoint how indigenous institutions shape collective action and responses to climate change in a given socioecological context. This empirical study will contribute to a body of literature on how collective action and adaptive capacity by rural indigenous institutions shape collective action and responses to climate change in rural settings. Moreover, it will provide a basis to guide policy debates and give specific recommendations to promote the role that indigenous institutions can play in promoting adaptation and development.

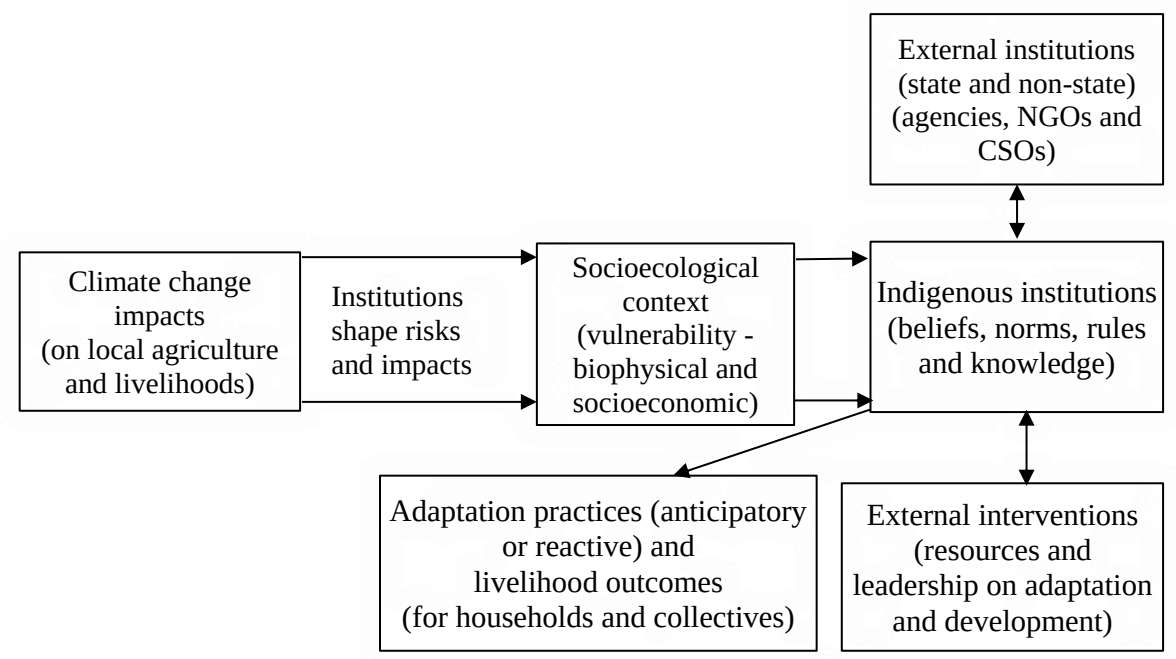

Figure 15. Adaptation, institutions and livelihoods framework (Agrawal and Perrin (2009).

5.2 Materials and methods

5.2.1 Study area and the Borana community

The study area, consisting of the Borana pastoral and agropastoral systems, is located in the arid to semi-arid areas of southern Ethiopia (3º36' and 6º38'N, and 36º43' and 41º40'E) encompassing seven administrative districts in the Borana Plateau (Fig. 16). The Borana administrative zone which includes the study area is broadly divided into two agroecological zones - the high-altitude humid lands to the north, and lower arid and semi-arid lowlands to

the south which constitutes significant vulnerability, which is the focus of this study (Tache and Irwin, 2003).

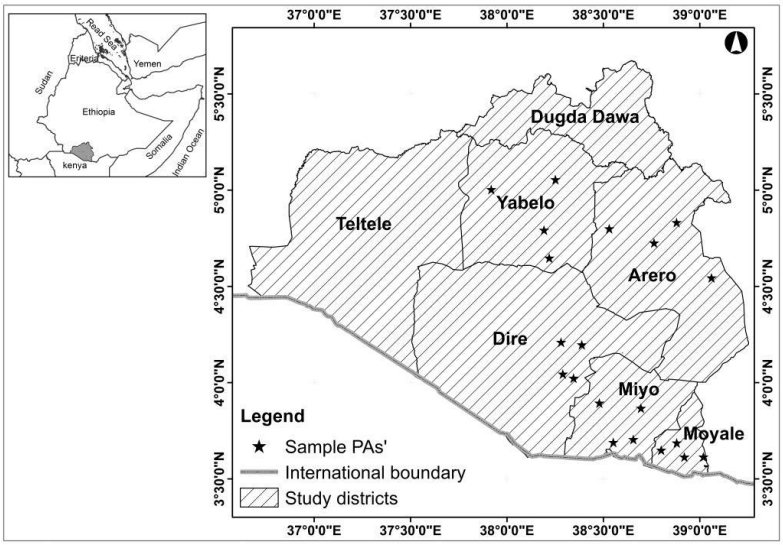

Figure 16. Map of the study area, Borana lowlands of southern Ethiopia (Note: PA=Pastoralist/agropastoralist association)

The Borana are semi-nomadic pastoralists and agropastoralists specializing in cattle, but may also keep camel and smaller livestock. Communities are dependent on ecological and environmental resources for their livelihoods and inhabit one of the most vulnerable ecosystems in the country. Social bonds, communal deliberations and learnings are all important in the everyday life of the Borana pastoralists and agropastoralists (Watson, 2003; Megersa et al., 2013). The Borana communities are relatively marginalized and have been heavily impacted by climate change mainly due to dependence on rainfed agricultural production systems (Tache and Sjaastad, 2010; Virtanen et al., 2011).

Indigenous institutions in the Borana (both formal and informal) operate under the auspices of the *ada seera* Borana (the customs and laws of the Borana). The Borana society is recognised as having one of the most resilient and comprehensive egalitarian and democratic political systems or indigenous institutional structures (called *Gada*) in east Africa. Leaders are elected to a position of authority through the will and active participation of the people they represent. They are elected to position of authority not only to keep laws and rules of the land but also are held accountable for decisions they take during their tenure as councillors of their own constituency and leaders of the Borana society in general. The system is governed

by the Adula council (committee) of elders of six men lead by their presiding officer called Abba *Gada* (father of *Gada*) but the structural complexities of the other components that make up the *Gada* system are challenging to understand (Legesse, 1973). Customary laws and traditional knowledge are integral components of the overarching *Gada* system that helped the Borana to endure challenges from pervasive changes in biophysical, socioeconomic and political changes (Watson, 2003). The role of indigenous institutions in relation to adaptation to climate change can be usefully explored through reference to the *Gada*.

5.2.2 Recruitment and sampling

Research participants were selected using stratified random sampling, one from each of 10 pastoralist/agropastoralist associations (villages) across five of the seven districts (i.e. one pastoralist and one agropastoralist each from Arero, Dire, Miyo, Moyale and Yabelo district). The ten institutional leaders and participants, invariably all men as woman are not traditionally involved, represented a diverse agroecologies and agricultural management practices. All were each actively involved in leadership which facilitates and shapes collective action relevant to household and communal responses to climate variability and change. This study is informed by the results from a related farm household survey and focus group discussions conducted across 480 farm households and 20 pastoralist associations from the same 5 districts.

5.2.3 Ethics statement

The Social Sciences Human Research Ethics Committee of the University of Tasmania approved the ethical standard of this project (Ref# H0012318). Assessing the ethical aspects of the research was aimed at protecting the welfare and the rights of the participants in this research. The purpose of the study was explained to each participant and written informed consent was obtained before the interviews were conducted. Participants were interviewed in-house and in the field - locations that were considered both safe and private by the ethics assessment. Every precaution was taken to ensure privacy and avoid distress and participants were informed they could halt the interview at any time and remove any part of the interview should they desire. Participant codes rather than names were used during the transcription, analysis and report writing stages to protect privacy and maintain anonymity.

5.2.4 Data collection interviews and analysis

The interviews were conducted following a semi-structured, one-on-one and open-ended format questionnaire (Appendix ii). The interview included questions on roles of institutions and other aspects related to institutional aspects of adaptation to climate change. Interviewees were first invited to identify the indigenous institutions which they considered as important for having roles in adaptation to climate change. Next, they were asked specific questions about their perspective and experience of the role of each indigenous institutions and their interlinkage and interaction with external institutions. The interview questions had been pre-tested by experts. All interviews were audio recorded and field notes were taken during the interviews, which on average took 25 minutes.

The interviews were transcribed from the local language (Oromo) verbatim in MS Word format and then were imported into NVivo (QSR International, 2012) as data records. The data were coded to nodes, and themes as identified from sets of the codes using a thematic analysis approach. This approach involved the identification of initial codes, followed by identification and reviewing of themes and then the definition of the final themes that emerged from interviewee responses (Fig. 17).

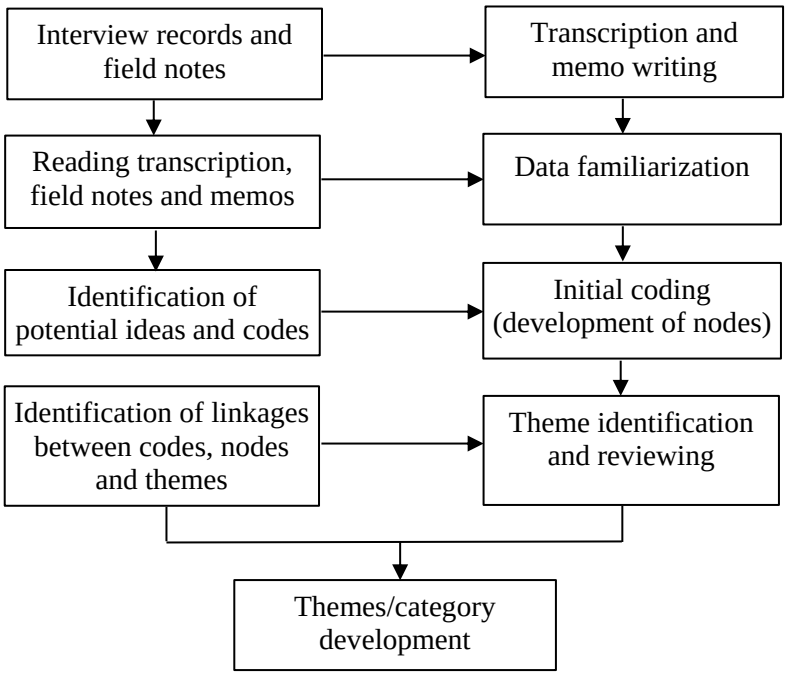

Figure 17. Thematic analysis procedures used to achieve themes/category development in NVivo.

The transcripts were coded separately by two individuals to ensure that the development of codes and themes was consistent. Emergent themes and concepts were then translated to English. Frequency analysis was performed as part of the data analysis and quotes from interviewees were used to triangulate key findings of the study from the interview.

5.3 Results

The interviewees identified three indigenous institutions that were involved with particular roles related to local climate change adaptation: 1) *finna marra fi bishani* (rules of range and water), 2) *busa gonofa* (customary social insurance system), and 3) *husa and aganhi* (traditional weather forecast and early warning systems). Table 10 gives a summary of these findings and considers each institution related to local adaptation as a theme.

Table 10. Overview of major indigenous institutions important in adaptation to climate change in the Borana lowlands, Ethiopia

Indigenous institution	Functionality	Main area of focus	Approach to adaptation	Interaction with state	Major challenges encountered
Rules of range and water *(Finna marra fi bishani)*	Community (pasture) and clan (water) level	Management of range and water resources	Proactive and/or reactive	Often negative	1) Divergent views on land tenure systems 2) Increasing human and livestock population
Social safety-net (*Busa gonofa*)	Community and Clan level	Social support and livelihood recovery	Reactive	Positive	1) Increasing number of destitutes, and 2) Declining number of well-off households
Weather forecast (*husa* and *aganhi*)	Community level	Weather forecast and early warning system	Proactive	Positive	1) Increasing unpredictability of seasonal climate*

*The lack of basis in reality of many of the traditional forecasting systems means even if based on "tacit knowledge" that knowledge is now less relevant.

Theme I: Regulating access to common-pool natural resources necessary for adaptation

Eight (80%) of the interviewees identified regulating access to communal pasture and water resources as key role played by a local institution called *finna marra fi bishani*. These two pasture and water management functions are integral components of the natural resource governance regime in the Borana but are slightly different management systems and warrant separate examination.

Category I: Water management

Interviewees underlined that water management is an important role of their traditional institutions that helped them endure highly variable climatic conditions. In Borana water sources are categorized into two - traditional and locally built water sources (traditional wells) and externally supported water points (such as hand pumps, cisterns, earth dams, etc). Traditional wells are the most culturally valued water sources and their management traditionally constitutes strong institutional arrangement.

Participants explained that the primary right to utilize the water well rested with the person who initially located or excavated the well called *aba konfi* (water overseer). However, the day-to-day operation and maintenance of the traditional well are run by a locally elected person called *aba herrega* (water manager) who is appointed by the *aba konfi*. The *aba herrega* is responsible for facilitating collective action in order to ensure the continuity of the well's operation. Unlike the rangeland management system which is organized on a wider community basis, access to water embraces a clan-based arrangement and rights are bestowed on a clan which suggests a differential access to water resources. However, for externally introduced water structures like ponds and cisterns, participants stated that the management involves locally elected water management committees but does not necessarily carry a clan-based arrangement. A local deep-water well manager narrated the importance of the rules of range and water as;

> *"We the Borana have ada seera (traditional rules) that regulate the use of our natural resources. We manage our communal pasture and water through a traditional institution called finna marra fi bishani (rules of range and water). We have people called abboti finna (rule overseers) who lead the management of our resources during dry/wet seasons and extreme events. We have the abba herrega (water manager) who looks after the daily operation and management of water points and surrounding rangelands to ensure fair access among resource users. When someone from the community tries to access our water points contrary to our traditional rules, the water manager has the responsibility to protect and enforce the rules. If accessed without his consent, he has the authority to fine the transgressor based on the provisions of traditional law. If the person disobeys him again, he will take the case to the next tier of management, our local elders, who are more vocal and capable of enforcing the law. For example, we recently fined someone fifty Ethiopian Birr for accessing a well to get livestock watered without the permission of the water manager, and for not complying with our customary laws." (Well manager, Moyale district, 008).*

Interviewees indicated that there were clear points of divergence between indigenous institutions and government structures in managing local water resources. For instance, the traditional water management system regulates access to water points based on distance and clan affiliations. In contrast, government structures encourage unlimited access to livestock water for communities, irrespective of distance and clan affiliation.

Further, interviewees expressed concerns about the development of new water points, which had been installed without adequately consulting the relevant indigenous institutions. Interviewees perceived this approach as misguided because it bypassed relevant indigenous institutions and weakened community efforts to manage range and water resources through consensus and collective action.

Category II: Range management

Communal rangeland management by the indigenous institution called *jarsa dheeda* (Committee for Range) was recognised by interviewees as another of the most important roles of an indigenous institution - providing rules on access to communal pasture. As for water resource management, the committee has the authority to build consensus on collective rangeland management and fine or sanction those who transgress the customary laws that govern access to communal pasture. As part of the management system, the committee may also set aside part of the communal grazing land for recovery or a reserve for drought periods in order to reduce communities' vulnerability to climate change

Interviewees explained that the Borana traditional land management system broadly identifies grazing areas based on whether they are used for dry or wet season grazing. As such, the rangeland management system recommends that the family herd is divided into either home based *warra* or satellite *forra* herds, with the latter moved to wet season grazing areas in fall-back regions far from encampments. The seasonal allocation of grazing land aims to ensure a balanced co-existence of communal pasture and water resources throughout the year. As for water resource management, interviewees recognised a clear divergence between traditional rules and state laws and policies on land tenure, which had gradually eroded and undermined the effectiveness of indigenous institutions (Table 10). A local elder highlighted the situation as;

"... we used to have strong traditional range and water management systems. In the old days, we had dry and wet season pasture reserves. When the weather was unfavourable, we managed our water and pasture resources to escape the feed shortage during

droughts. Because of the uncontrolled settlement, those previously unsettled protected areas are now being settled and nearby rangelands are used year-round. Now encampments are very close to each other, approximately in a radius of less than five kilometres. We don't have much space to move in between encampments. I believe population growth (human and livestock) partly contributes to this problem. Before there were protected wet season grazing areas - which we used only when there was rain - then we left these wet season grazing areas and went to dry season grazing areas. This gave the rangeland time to recover. For instance, in the fall-back region called Golbo, there was no permanent water point and for many years we used it as a wet season grazing area. Now, they (state and non-state development actors) have put in permanent water points and it has become a year-round grazing area which has resulted in overgrazing. It is difficult to move the herd to this place as a wet season pasture reserve anymore which has put pressure on us. Therefore, due to increasing feed shortage and drought we are now keeping to goats and camels which better cope with drought conditions than cattle." (Local elder, Dire district, 003).

Theme II: Facilitating support for post-shock livelihood recovery

Seven interviewees (70%) stated that indigenous institutions in Borana played a critical role in facilitating social support for post-shock livelihood recovery for those families affected by climate change. This indigenous institution called *busa gonofa* functioned as a traditional often clan-based social safety-net and livelihood security system. As part of *busa gonofa*, households affected by climate-induced stress, for example drought, receive livelihood support from well-off fellow clan members, mainly by contributions of animals to restock the family livestock. These contributions are organised at a clan based assembly called *kora debanu*, a post-shock clan-based convocation. A local elder highlighted the situation as;

"When there is severe drought there are vulnerable families that lose their livestock and agriculture-based livelihoods. For this, we have a traditional social support system called busa gonofa to assist affected families in their efforts to recover from effects of climatic stressors and shocks. This type of support could also extend to those households affected by other calamities such as conflict or theft. For instance, if the victims are from Digalu clan, then clan members will identify and prioritize those families in need and discuss among themselves how to mobilise support. Elders identify those relatively well-off clan members and determine contributions in terms of heads of livestock, mainly cattle. When a well-off clan member is not willing to contribute to his share, we have a system called jinfu whereby the clan puts pressure on that particular well-off clan member to give the contribution assigned by clan elders. Clan members can even forcefully take cattle to give to the victimized families which are meant to be helped." (Well overseer, Moyale district, 007).

Interviewees also noted the contemporary challenges of maintaining a functional *busa gonofa*, particularly in the face of increasingly frequent droughts. Households that had previously been able to provide contributions are now less able to donate because they themselves are losing an increasing number of livestock. A participant described the situation as;

"In recent times our traditional social support system is getting weaker. In the old days, those who had five heads of cattle could contribute one to those families who did not have any through a collective decision taken by the community. These days we do not have as many cattle as before and are not able to give to each other like we did in the past. But when my cow gives birth and starts to lactate, I share milk with others. I question how a person who does not have anything can support others deprived of drought? It is true that in the past when a thief takes cattle we used to support each other. When families became poor we gave to each other. We still have this culture, but we are losing the capacity to assist the recovery of deprived families. There is a saying in our culture, (referring to the old days when horses were used for transport), a poor person loads up his horse so that he can carry his goods but then a poorer person comes along and wants the horse to also carry his goods (Well manager, Miyo district, 005)."

Theme III: Supporting the traditional climate forecast and early warning system

Three of the interviewees (30%) identified indigenous institutions as having an important role in supporting the traditional climate forecast and early warning system. Interviewees stated that the traditional forecast systems involved readings of *husa* (reading animal intestines) and *aganhi* (reading stars) by local experts. The weather forecast is followed by community-based early warnings to prompt farm households and communities to take proactive adaptive action in the face of anticipated change in climate conditions. A local elder narrated the situation as;

"…Traditionally we have weather forecast systems that hint at what will happen in the near future in relation to conflict and climate (mainly rainfall) - which will impact the availability of pasture and water resources. Based on such these early warnings, we prepare ourselves and act accordingly – whether this is for drought or conflict. We have different weather forecast systems - most common are husa and aganhi. In husa, gifted people locally known as uchu, read the intestines of slaughtered livestock and predict likely rainfall conditions and the likelihood of conflict. They give interpretations which tell us about pasture and water availability for livestock, and the probability of resource-based conflict with other social groups. Through this traditional early warning system elders prompt the community to prepare to adapt to for what is likely to happen in the near future. Aganhi refers to our customary system whereby men locally known as ayantu observe the orientation and assortment of the stars and forecast important events that may influence our access to rangeland, water and peace." (Local elder, Arero district, 002).

Despite a strong dependency on traditional rainfed agriculture for their livelihoods, the participants noted that they had limited access to climate information provided by the public services of the National Meteorology Agency and as a result were reliant on traditional forecast system which is now challenged by the perceived decreasing predictability of weather conditions.

5.4 Discussion

In this study, in-depth interviews with ten elders representative of the Borana community identified three key indigenous institutions as having important respective roles in - 1) regulating access to collective natural resources (water and pasture) required for adaptation, 2) facilitating support for post-shock livelihood recovery, and 3) providing traditional climate forecast and early warning systems which represent a manifestation of tacit local knowledge. The study provided insights on the importance and dynamism of indigenous institutions involved in adaptation to climate variability and change. The significance of these roles is also supported by data presented in Chapter 4 which examines household options and barriers to climate change where indigenous institutions are at play in the study area.

Results suggested that indigenous institutions supported adaptation through enabling collective action, improving adaptive capacity and shaping responses to climate shocks and stressors. Indigenous institutions have often been shown to provide enabling environments through pooling, reducing or avoiding climate risk across temporal and spatial scales in many other developing countries which is in agreement with findings of Agrawal and Perrin (2009). For example, Yami et al. (2011) reported that informal institutions provided the mechanism to address communal land use management problems such as overexploitation of communal rangelands in Tigray region of northern Ethiopia. Specifically, in the Borana, the *Gada* system provides leadership, resources, rules, norms and knowledge to facilitate local level decision-making and to enable adaption to climate change, which is consistent with previous studies of (Watson, 2003). The findings suggest the critical role indigenous institutions play in enabling communities to take collective action in favour of their collective interest such adaptation.

Along with the natural and physical capital, our study clearly indicated that local institutions and social capital provided adaptive capacity, shaped responses and increased livelihood security. The interviewees stated that the local safety-net system increased livelihood security for most vulnerable social groups in the face of limited access to income-

generating activities. As reported by other authors (Legesse, 1973; Watson, 2003; Homann, 2004) indigenous safety-net systems should contribute support especially to drought victims. Although *busa gonofa,* remains a key resilient social security system in supporting the adaptive capacity of smallholders, interviewees noted the challenge of maintaining a functional *busa gonofa,* particularly in the face of more frequent drought events. Berhanu (2011) emphasizes that the collective lifestyle and strong social capital in the Borana must be valued by external stakeholders working on adaptation and development. Local institutions enhance collective action and reduced vulnerability for vulnerable social groups.

Rural communities in the Borana system greatly relied on these community-based indigenous institutions to regulate access to water resources and its overall management including its maintenance. Adaptive management of these natural resources appears profoundly linked to the traditional resource governing structures of the Borana community. Water resources (wells, ponds, cisterns and surface depressions with traditional deep wells (*ella*) built centuries ago) form a critical source of water for dry season grazing and are traditionally seen as valuable common property resources regulated traditionally (Watson, 2003; Kamara et al., 2004; Homann et al., 2008a). Seasonal grazing control in rangeland management is based on access and availability of these permanent deep-wells (Desta and Coppock, 2004) which suggests the interdependency water and pasture management systems. In general, indigenous institutions shaped current adaptation and structured future adaptation by households and communities.

Analysis of the interviews indicated that the institutional linkages between formal and informal institutions in the Borana are an important aspect of how institutions operate in the Borana in relation to adaptation. For example, indigenous institutions were engaged in governing collective natural resources in the study area. In the past two decades, there has been a clear divergence between traditional rules and state land policies, a divergence which has gradually eroded and undermined the effectiveness of indigenous institutions in managing natural resources (Table 10). In accordance with the *ada Borana*, all land belongs to the Borana community and as such promotes collective use while the state encourages individual user rights. The national settlement policy encourages privatization of agricultural land through motivating pastoralists living in scattered encampments to come together and form a village and lead a sedentary lifestyle which eventually results in fragmented and isolated pastoral ecosystems. State agencies claim that the development of villages facilitates the provision of basic public services like health, education and electricity (Tsegaye et al., 2010). Traditional land tenure systems, however, do not usually allow the expansion of encampments

or encourage sedentary living. This puts communal range and water resources under pressure and weakens the authority of indigenous institutions whether in Ethiopia (Homann, 2004) or other countries with nomadic peoples such as Mongolia (Zampaligré et al., 2014). This scenario clearly highlights the importance of institutional interlinkages in determining efficiency and effectiveness with which indigenous institutions have a role.

More specifically, one of the consequences has been the annexation of communal grazing land for privatized cultivation and pasture reserves resulting in the fragmentation and shrinking of the communal grazing land. The impact of interference by government actors with indigenous institutions and privatisation of land can be seen across traditional farming systems in Africa (Watson, 2003; Tefera et al. 2007). For example, Makepe (2006) reported that the de-legitimization of indigenous institutions that managed resources and conversely, the reinforcement of state institutions that encouraged privatisation of communal lands has resulted in the exploitation of communal rangelands in Botswana. He argued that dismantling and delegitimization of traditional resource governing institutions resulted in resource overexploitation. Hardin (1968) describes in his tragedy of the commons theory how institutions effective in managing common property resources are important in considering the best interests of the community by preventing the overexploitation of resources being used. Similarly, authors such as Zampaligré et al. (2014) advocate the devolution of individual property rights back to local communities and indigenous institutions that promote collective action.

Despite strong dependency on traditional rainfed agriculture for their livelihoods, the interviewees noted that they had limited access to climate information from official meteorological services. Instead they relied on traditional forecast systems such as *husa* and *aganhi* and other weather forecast methods that involved interpreting the behaviour of wild animals, cloud cover and type, constellation of stars, blossoming of trees, migration of bird species. In a similar study Nyong et al. (2007) indicated that traditional forecast methods using indigenous knowledge are used in adaptation to climate change in rural Sahel. Although the traditional forecast systems seem not to be based on sound scientific foundations, they often arrive at relatively ‘correct’ answers based on cumulative agroecological knowledge and skills gained through heuristic experience, as explained by Michael Polanyi’s concept of ‘‘tacit knowledge’’ (Polanyi, 1966). In addition, Luseno et al. (2003) and Zuma-Netshiukhwi et al. (2013) found traditional forecast systems to be popular among pastoralists in many parts of sub-Saharan Africa including farming communities in northern Kenya and southern Ethiopia (Speranza et al., 2010) and farmers in South Africa (Zuma-Netshiukhwi et al., 2013).

In the face of increasing climate variability and unpredictability, there is strong uncertainty about the accuracy and relevance of these traditional forecast systems that necessitate the introduction of reliable climate information services. It should be understood that, in the absence of science-laden weather forecast services from meteorological sources, the traditional systems provide a context for adaptation to anticipated changes in climate. But we suggest that improved adaptation can be achieved through integration of the traditional forecast system and meteorological information so that adaptation decisions can be well informed in a locally specific manner.

Despite the important roles indigenous institutions play in adaptation to climate change, they are constrained by a number of internal and external challenges. De-legitimization of indigenous institutions is an important aspect of the issue influencing their role. Results suggested that the state's lack of engagement with indigenous institutions was considered by elders as a major cause of the weakening role of indigenous institutions - a view that is consistent with previous studies of the Borana people (Homann et al., 2008a). Muller-Mahn et al. (2010) highlighted that during the establishment of large-scale irrigation schemes in Ethiopia top-down state interventions undermined the authority of indigenous leaders and their institutions. That detrimentally impacted Kereyu and Afar pastoralists by reducing the efficacy with which the elders regulated access to collective natural resources. Improved outcomes could be achieved if indigenous institutions were meaningfully integrated into external interventions relevant to adaptation. Despite the challenges, these institutions shaped local responses to climate change, increased livelihood security and reduced vulnerability in these areas rendered vulnerable to climate change and its effects whereby livelihood options are limited and government engagement in terms of providing services is relatively lower.

5.5 Conclusion

In this study, we reveal how institutions structure collective action, influence adaptive capacity and shape responses of rural households and communities to climate change and its effects. They constitute untapped and resilient resources to enhance adaptive capacity and increase livelihood security in the face of limited livelihood options and rapidly changing climate conditions. In particular, roles played by indigenous institutional in terms of regulating access to natural resources, facilitating post-shock livelihood recovery and providing climate forecast and early warning systems are key to enhance adaptive capacity and support adaptation. These institutions enjoy a significant level of trust from local communities who also understand their value and relevance to local adaptation in the face of

limited external support. However, as indicated in Table 8 considerable changes in local circumstances are putting pressure on the ability of the local institutions to deliver the desired outcomes and allow these institutions to evolve their role.

The results also suggested that interlinkages between Borana indigenous institutions, and state development agencies were largely about competing for authority over resource management. Among the communities, there is a tendency of looking state intervention as interfering rather than supporting local adaptation and development that values the favoured traditional lifestyle. Misguided water development, sedentarization of pastoralists and the privatization of land for cultivation and private grazing were notable examples of divergent views between traditional institutions and state agencies. Such types of conflicts constrain the role of indigenous institutions in supporting adaptive capacity. Despite attempts to overlook and de-legitimize these institutions, they appear to be resilient entities that have supported adaptation to climate stimuli for generations.

Our results confirm the claim that future plans on adaptation and development of traditional farming systems such as those in Borana should be inclusive of local institutions including indigenous ones. Pastoralists and pastoralism are not well represented in relevant national policies. Indigenous institutions should be integrated within development agencies to better address local adaptation needs and livelihood challenges thereby addressing path dependency and inefficiency. This integration would ensure that external interventions are effectively coordinated with relevant indigenous institutional structures and build on local resources, governance structures and traditional adaptive capacity. For example, the incorporation of a science-based weather forecast, the extension of community involvement (e.g. women) and the recognition of increasing pressure on the natural resource base are important issues to address.

Acknowledgements

The authors are grateful to the research participants who dedicated their time and shared their views and experiences on the institutional context of adaptation in the Borana pastoral and agropastoral systems. We also extend our thanks to Belay Simane for his technical support during the fieldwork and Jarso Dubo in facilitating individual interviews and community discussions.

Chapter 6: General discussion and conclusions

6.1 Objectives and designs of the study

Smallholders in Ethiopia including pastoralists and agropastoralists are highly vulnerable to climate change due to their dependence on rainfed agriculture and limited adaptive capacity (Temesgen and Rashid, 2009; Arndt et al., 2011; McIntosh et al., 2013). Despite the need to rapidly adapt to the ongoing change in climate conditions, the research in this area has been fragmented and their remains large gaps in knowledge. Those studies that have examined adaptation to climate in developing countries have mainly focused on exploring adaptation practices for mainstream mixed crop-livestock systems. Whereas research on adaptation in pastoral and agropastoral areas is scant. Successful adaptation, however, requires a better understanding of the key elements of the adaptation process such as how changes in perception can influence decisions to adapt and the roles played by various actors including institutions.

The major objectives of this thesis research were to - 1) assess how climate change and its effect is perceived among rural households and communities (both as a problem and context), 2) examine agricultural adaptation options and barriers to successful adaptation, and 3) analyse the contribution of indigenous institutions in adaption to climate change. The study made use of the combination of the Pressure-State-Response (PSR) and Adaptation, institutions and livelihood (AIL) analytical frameworks which provide the strong basis to systematically and meaningfully analyse local adaptation. A thorough understanding of the smallholder perspective of climate change and adaptive strategies they employ will be helpful for designing programs, improving outcomes and mainstreaming adaptation particularly in rural communities of developing countries. The research drew insights from previous and current adaptation options and barriers to adapt in smallholder agricultural systems in order to facilitate successful adaptation in the future. Adaptation is critical as it helps reduce the potential impact of climate change (without adaptation) to actual impact (impact after adaptation) across the agriculture sector. Moreover, the study analysed key roles indigenous institutions play in supporting adaptation through shaping collective decisions, structuring vulnerability and shaping responses.

The thesis research employed both qualitative and quantitative study approaches to examine data obtained from rural household surveys, key informant interviews, and focus group discussions. The study focused on the Borana pastoral and agropastoral systems where

traditional farms and agriculture-dependent livelihoods exhibit substantial level of vulnerability. Major findings of the thesis are summarized in Table 11.

Table 11. Summary of the major findings from the result chapters based on research questions as formulated in chapter 1

Research questions		Main findings	Chapter
I	Farm households' perception of climate change	An overwhelming majority (96%) of farm households perceived climate change and its negative impact on local agriculture and livelihoods while perceived level of change is significantly affected by various household and farm attributes. Perceived change is not necessarily substantiated by meteorological evidence.	3
II	Farm households' response to climate change	Farm households and communities employed diverse adaptation options mainly through adjusting farming practices and diversifying into non-pastoral livelihoods that embrace resilience or incremental adaptation while transformational adaptation is lacking. Indigenous knowledge and practices are crucial inputs, and adaptive capacity is constrained by set of multiple barriers.	4
III	Role of rural indigenous institutions in adaptation	Indigenous institutions played important yet weakening roles in enabling smallholders adaptation mainly through regulating access to common-pool resources required for adaptation, facilitating post-shock livelihood recovery and supporting traditional climate forecast and early warning systems.	5

In section 6.2, we briefly discuss the three research components undertaken with the Borana communities and in 6.3 their significance to improving local adaptation to climate change. A general conclusion and potential future research areas are given in section 6.4.

6.2 The roles played by perception of climate change and indigenous institutions in adaptation

1. Perception of climate change and its impact by smallholders in pastoral/agropastoral systems of Borana, south Ethiopia.

Adaptation to climate change in agriculture requires perception of climate change and its risk to agriculture and livelihoods, both as a problem and context. Perception prompts the need for

conscious adaptation, subsequent decisions to adapt and employ internal and external assistance mechanisms for adaptation (Maddison, 2007). We considered the perception of climate change as prerequisite to the discussion of adaptation options and barriers, and institutional capacity for adaptation. Moreover, perception of climate change consistent with meteorological evidence is critical for appropriate problem analysis, an important input for successful adaptation. Otherwise, misperception of the actual climate change represents an inappropriate diagnosis of the problem and has significant implications for successful adaptation including incurring transitional losses.

Smallholder perception of climate change during a 20 year study period (1992-2012) and its associated impact on local agriculture were investigated. Data were obtained from farm household surveys conducted in 5 districts, across 20 pastoral/agropastoral associations and 480 farm households of Borana in southern Ethiopia. Despite limited meteorological evidence of significant climate change during 1992 and 2012, the results suggested that irrespective of household and farm attributes, most participants had an overwhelming perception that climate was changing and exerting a negative impact on agriculture. Climate change was mainly felt in terms of increased temperature and reduced rainfall (frequent seasonal droughts) whereby the former is consistent with meteorological evidence and the latter was found difficult to clearly substantiate. It is likely that the perception of declining rainfall might be triggered by recent drought events as a result of extreme climatic conditions.

Perception levels were significantly affected by household and farm attributes such as livestock holding, level of attained education, access to support services such as climate information and extension services. In contrast, household size, farm and non-farm income levels, farming experience and type of production system did not significantly affect perception levels. Smallholders attributed climate change to a range of biophysical, deistic and anthropogenic causes. Results highlighted the need for enhancing awareness of the risks associated with climate change. Smallholders must have realistic expectations and be better prepared not only so they can cope with the negative impacts but also take advantages of any opportunities associated with a changing climate.

2. Options for and barriers to climate change adaptation in pastoral/agropastoral systems of Borana, southern Ethiopia.

A mixed-method research approach was used to interrogate the adaptation options employed to manage risks of climate change among the Borana pastoralists/agropastoralists communities. We used a combination of frameworks (the Pressure-State-Response (PSR) and

Pelling's typology of adaptation) to analyse data obtained from farm household surveys (n=480), community focus group discussions and expert consultations. Findings showed that the communities mostly relied on indigenous methods of adaptation whereby traditional knowledge and practices, and the role played by indigenous institutions were key to adaptation. Local adaptation options included livestock supplementary feeding, off-farm employment (non-pastoral occupations), herd mobility, livestock sales, water developments, social safety-nets, receiving food aid and livelihood diversification (growing crops and/or herd diversification). Smallholders were clearly making a shift into more diversified livelihood systems such as moving from cattle dominated livestock enterprises to mixed and diversified herd structures. Moreover, they practiced cultivation by integrating crop and livestock enterprises suggesting a shift to agropastoralism.

Based on Pelling's topical framework, the smallholders largely pursued resilience (stability) and transitional (incremental change) adaptation pathways to avoid major system disruptions and to bring marginal changes rather than adopt any long-term sustainable transformational approaches. Adaptation options tended to be reactive in nature, not proactive or anticipatory risk-based approaches. In addition, some adaptive measures tended to lead to maladaptation harming the future capacity of communities to adapt to future changes. While there were continued efforts to adapt, there is little evidence that adaptation significantly reduced vulnerability and improved livelihoods. Wide spread food insecurity and deepening poverty with eroded resources for future adaptation are key examples. The results suggested that smallholders had yet to realise any beneficial opportunities climate change may offer in terms of investment and diversification of livelihoods.

Despite efforts to adapt to climate change, this study showed that the adaptive capacity of pastoral/agropastoral systems of Borana is constrained by a range of barriers and that these systems are highly vulnerable to climatic stresses. Major barriers include a shortage of financial resources, limited technical assistance (including climate and extension services), cultural bias and limited policy support to encourage local level adaptation. External support for local adaptation pathways appeared limited and the government's push for ''modernizing agriculture'' undermined the smallholder traditional approach to adaptation and traditional lifestyle, pastoralism. Therefore, adaptation pathways that build on local resources and address the key barriers to enhancing adaptive capacity are crucial to ensure functioning of these fragile agricultural systems.

3. Role of indigenous rural institutions in adaptation to climate change in Borana pastoral/agropastoral systems, south Ethiopia

Adaptation to climate change involves policies, practices and institutions. Institutions, particularly indigenous ones, play a crucial role in facilitating adaptation at the local level among rural traditional communities. Thus, better insight of how institutions engage in local level adaptation and interact with other counterparts will allow development program managers to integrate external actors and interventions with local institutions. The last step of my study was to assess the enabling role of indigenous institutions in the study area in respect to climate change adaptation. Data were collected from interviews of a total of 10 individuals representing 5 districts and 10 different pastoral and agropastoral associations or villages. Data were processed using NVivo software and then analysed using a thematic analysis approach. The important role of indigenous institutions in the Borana community is consistent with previous studies that showed indigenous institutions underpin everyday life of the Borana where a strong social tradition of resource sharing is common (Homann et al., 2008b; Tache, 2008). The study identified three key distinct roles indigenous institutions play in facilitating adaptation to climate change - 1) regulating access to common-pool natural resources required for adaptation, 2) facilitating support for post-shock livelihood recovery which increased livelihood security for vulnerable social groups, and 3) supporting the traditional climate early warning systems which are based on tacit knowledge of the environment. Institutions achieve this through shaping collective action and responses to climate shocks and stressors.

The indigenous institutions enabled adaptation through providing resources, rules, norms and knowledge to facilitate local level decision-making. However, the results also found that the roles of indigenous institutions in collective resource management were weakening, due to past misguided top-down interventionist approaches of state and non-state development stakeholders on different aspects including on land tenure systems. Interference by state laws had disrupted local rules and norms used to manage natural resources and resulted in expanding private cultivation of communal rangelands and uncontrolled settlement. The expansion has threatened the welfare of pastoral systems and environmental sustainability by resulting in exploitation and degradation of communal resources. Nonetheless, indigenous institutions remain resilient and critical in Borana where strong social capital and tradition of resource sharing is common (Tache, 2008). In this regard, the Borana community are well known to have one of the most comprehensive indigenous institutional systems, called *Gada*.

6.3 Significance of my research for climate change adaptation by the Borana pastoralists and agropastoralists and similar smallholder farming systems in developing countries

- *Helps external actors to understand local opinion about climate change both as a problem and context, and more effectively engage local communities in planning adaptation*

This study is particularly relevant to pro-poor agricultural adaptation whereby dependence on rainfed agriculture and resource constraint are important issues. As much as understanding the adaptation needs of communities and systems is important, understanding the perception of those at the centre of the problem is equally critical. Access to the type of information from my study will 1) guide programs to promote awareness about climate change, 2) help understand the human and behavioural aspects of the environment in which adaptation is intended, and 3) meaningfully engage those at the centre of the problem and ensure willing cooperation and appropriate support for adaptive policies and programs.

- *Identifies adaptation options and barriers to provide state and non-state actors the entry point for action to promote successful adaptation*

The increasing level of climate change induced vulnerability and risk in climate-sensitive sectors like agriculture in the Borana necessitates rapid and effective adaptation. Therefore insight into adaptation options and barriers involved is vital to inform future adaptation. Adaptation is an iterative process and actors must learn from past and ongoing adaptation processes to build on those knowledge and experiences to improve future adaptation outcomes. The research also helps to identify entry points for actions in order to overcome barriers and limits that impede adaptation processes and outcomes.

- *Provides insight on the institutional context of local adaptation*

Understanding power relations, policy and knowledge context of the environment in which adaptation takes place is crucial for any external actors. In traditional societies, indigenous institutions are vital actors that collective decision-making and resource governance are an integral part of everyday life. This study identified the key roles indigenous institutions of the Borana play in local adaptation, how indigenous institutions interact with external institutions and the impact of these interactions on the processes and outcomes relevant to adaptation. How institutions engage in local level adaptation is important information for external actors (e.g. adaptation and development program managers). The information can be used to ensure

better integration of external interventions with indigenous institutions and improved climate adaptation outcomes.

6.4 Conclusion and recommendations

Climate variability and change, especially predicted weather extremes such as severe drought, are key to any debate which is seriously concerned with the future of pastoralism and agropastoralism in the Borana. Understanding climate change in the area as a problem and context which involves awareness of important aspects of climate change, and appropriately responding to this problem to ensure successful adaptation remain key elements of this debate.

Awareness about climate change is immense among smallholders but current climate change adaptation strategies bring marginal and incremental changes and only envision short-term resilience and transitory goals, respectively. Socioeconomic factors such as population growth, changes in land tenure systems and the expansion of sedentary agriculture are however important attributes that determine local responses and choice of adaptive measures. Interference on the part of the Ethiopian government has resulted in rangeland encroachment and weakening institutions, fragmenting pastoral ecosystems into spatially isolated systems. It is clear that pastoral and agropastoral systems will become increasingly vulnerable if current government policies continue to pursue a top-down interventionist development model aimed at "modernising" agriculture while undermining indigenous institutions. The top-down interventionist development model further increases socioeconomic and ecological vulnerability which is not a desirable change for farming communities.

The likely impact of these substantial biophysical and socioeconomic challenges raises a question about the sustainability of pastoralism as a viable livelihood system without conflict and extreme poverty. However traditional pastoralism in dryland Africa may be considered as a dynamic process of adapting to unpredictable climatic variability amid pervasive changes in non-climatic forces as intervening factors. Pastoral adaptations and climate-induced innovative coping mechanisms are strategically embedded in the indigenous social structures and resource management value systems. Future adaptation should be planned in a forward-looking manner which sustainably builds on local resources including indigenous knowledge, practices and institutions.

To be successful climate change adaptation strategies must be dynamic, reflect local circumstances, respond to the diversity and heterogeneous nature of these smallholder farms and be sensitive to varying vulnerability conditions. Vulnerability should be understood as a dynamic and context-specific problem. Researchers, practitioners, and policy makers should

collaborate to develop coupled human and natural systems that simultaneously build resilience and enhance long-term adaptation building on local resources. Moreover, future research should give attention to other climate adaptation knowledge systems that complement indigenous knowledge systems in Borana.

References

Adger, N 2006, 'Vulnerability', *Global Environmental Change*, vol. 16, pp. 268-281.

Adger, N, Arnell, N and Tompkinsa, E 2005, 'Successful adaptation to climate change across scales', *Global Environmental Change*, vol. 15, pp. 77–86.

Adger, N, Dessai, S, Goulden, M, Hulme, M, Lorenzoni, I, Nelson, R, Naess, O, Wolf, J and Wreford, A 2009, 'Are there social limits to adaptation to climate change?', *Climatic Change*, vol. 93, no. 3-4, pp. 335-354.

Adger, N, Huq, S, Brown, K, Conway, D and Hulme, M 2003, 'Adaptation to climate change in the developing world', *Progress in Development Studies*, vol. 3, no. 3, pp. 179-195.

Admassie, A and Abebaw, D 2014, 'Rural poverty and marginalization in Ethiopia: a review of development interventions', in Jv Braun and FW Gatzweiler (eds), *Marginality: Addressing the Nexus of Poverty, Exclusion and Ecology*, Springer Publishing, pp. 269-300.

Agarawal, A 2008, 'The role of local institutions in adaptation to climate change', Washington DC.

Agrawal, A and Perrin, N 2008, *Climate adaptation, local institutions, and rural livelihoods*, University of Michigan, Michigan, USA.

Agrawal, A and Perrin, N 2009, 'Climate adaptation, local institutions and rural livelihoods', in N Adger, I Lorenzoni and K O'Brien (eds), *Adapting to climate change: Thresholds, values, governance*, Cambridge University Press, Michigan, USA, pp. 350-367.

Ahn, W-k, Kalish, C, Medin, D and Gelman, S 1995, 'The role of covariation versus mechanism information in causal attribution', *Cognition*, vol. 54, no. 3, pp. 299-352.

Akerlof, K, Maibach, E, Fitzgerald, D, Cedeno, A and Neuman, A 2013, 'Do people "personally experience" global warming, and if so how, and does it matter?', *Global Environmental Change*, vol. 23, no. 1, pp. 81-91.

Amdu, B, Ayehu, A and Deressa, A 2013, *Farmers' perception and adaptive capacity to climate change and variability in the upper catchment of Blue Nile, Ethiopia*, 77, The African Technology Policy Studies Network (ATPS), Nairobi, Kenya, January 2013, Working Paper #7.

Angassa, A and Oba, G 2007, 'Relating long-term rainfall variability to cattle population dynamics in communal rangelands and a government ranch in southern Ethiopia', *Agricultural Systems*, vol. 94, no. 3, pp. 715-725.

Antwi-Agyei, P, Fraser, EDG, Dougill, AJ, Stringer, LC and Simelton, E 2012, 'Mapping the vulnerability of crop production to drought in Ghana using rainfall, yield and socioeconomic data', *Applied Geography*, vol. 32, no. 2, pp. 324-334.

Aragie, E 2013, *Climate change, growth and poverty in Ethiopia*, The University of Texas, USA.

Araya, A and Stroosnijder, L 2011, 'Assessing drought risk and irrigation need in northern Ethiopia', *Agricultural and Forest Meteorology*, vol. 151, no. 4, pp. 425-436.

Arndt, C, Robinson, S and Willenbockel, D 2011, 'Ethiopia's growth prospects in a changing climate: A stochastic general equilibrium approach', *Global Environmental Change-Human and Policy Dimensions*, vol. 21, no. 2, pp. 701-710.

Ashenafi, Z and Leader-Williams, N 2005, 'Indigenous common property resource management in the central highlands of Ethiopia', *Human Ecology*, vol. 33, no. 4, pp. 539-563.

Awulachew, B and Ayana, M 2011, 'Performance of irrigation: an assessment at different scales in Ethiopia', *Experimental Agriculture*, vol. 47, pp. 57-69.

Awulachew, B, Merrey, J, Kamara, B, Van Koppen, B, Penning, V and Boelee, E 2005, *Experiences and opportunities for promoting small-scale/micro irrigation and rainwater harvesting for food security in Ethiopia*, 98, International Water Management Institute (IWMI), Colombo, Sri Lanka, 2005, ISBN 92-9090-612-x, Working paper #98.

Bacha, D, Namara, R, Bogale, A and Tesfaye, A 2011, 'Impact of small-scale irrigation on household poverty: empirical evidence from the Ambo district in Ethiopia', *Irrigation and Drainage*, vol. 60, no. 1, pp. 1-10.

Barnett, J and O'Neill, S 2010, 'Maladaptation', *Global Environmental Change*, vol. 20, no. 2, pp. 211-213.

Bassi, M 2005, *Decisions in the shade: Political and juridical processes among the Oromo-Borana.* , vol. 14, Oromo Studies Journal, Red Sea Press, Trenton, NJ.

Baudoin, M 2013, 'Enhancing climate change adaptation in Africa: assessing the role of local institutions in Southern Benin', *Climate and Development*, vol. 6, no. 2, pp. 122-131.

Belaineh, L, Yared, A and Woldeamlak, B 2013, 'Smallholder farmers' perceptions and adaptation to climate variability and climate change in Doba district, west Hararghe, Ethiopia', *Asian Journal of Empirical Research*, vol. 3, no. 3, pp. 251-265.

Belay, K, Beyene, F and Manig, W 2005, 'Coping with drought among pastoral and agropastoral communities in eastern Ethiopia', *Journal of Rural Development*, vol. 28, pp. 185-210.

Benjaminsen, A and Ba, B 2009, 'Farmer-herder conflicts, pastoral marginalisation and corruption: a case study from the inland Niger delta of Mali', *The Geographical Journal*, vol. 175, pp. 71-81.

Berhanu, W 2011, 'Recurrent shocks, poverty traps and the degradation of pastoralists' social capital in southern Ethiopia', *African Journal of Agricultural and Resource Economics*, vol. 6, no. 1.

Berkhout, F 2012, 'Adaptation to climate change by organizations', *Wiley Interdisciplinary Reviews: Climate Change*, vol. 3, no. 1, pp. 91-106.

Berman, R, Quinn, C and Paavola, J 2012, 'The role of institutions in the transformation of coping capacity to sustainable adaptive capacity', *Environmental Development*, vol. 2, pp. 86-100.

Berrang-Ford, L, Ford, J and Paterson, J 2011, 'Are we adapting to climate change?', *Global Environmental Change*, vol. 21, no. 1, pp. 25-33.

Bewket, W and Conway, D 2007, 'A note on the temporal and spatial variability of rainfall in the drought-prone Amhara region of Ethiopia', *International Journal of Climatology*, vol. 27, no. 11, pp. 1467-1477.

Birhanu, B and Geert, S 2013, 'Drought vulnerability drives land-use and land cover changes in the Rift Valley dry lands of Ethiopia', *Agriculture, Ecosystems and Environment*, vol. 164, pp. 100-113.

Bisaro, A, Wolf, S and Hinkel, J 2010, 'Framing climate vulnerability and adaptation at multiple levels: Addressing climate risks or institutional barriers in Lesotho?', *Climate and Development*, vol. 2, no. 2, pp. 161-175.

Boru, D, Schwartz, M, Kam, M and Degen, A 2014, 'Cattle reduction and livestock diversification among Borana pastoralists in southern Ethiopia', *Nomadic Peoples*, vol. 18, pp. 115–145.

Brulle, R, Carmichael, J and Jenkins, C 2012, 'Shifting public opinion on climate change: an empirical assessment of factors influencing concern over climate change in the U.S., 2002–2010', *Climatic Change*.

Bryan, E, Deressa, T, Gbetibouo, A and Ringler, C 2009, 'Adaptation to climate change in Ethiopia and South Africa: Options and constraints', *Environmental Science and Policy*, vol. 12, no. 4, pp. 413-426.

Bryan, E, Ringler, C, Okoba, B, Roncoli, C, Silvestri, S and Herrero, M 2013, 'Adapting agriculture to climate change in Kenya: household strategies and determinants', *Journal of Environmental Management*, vol. 114, no. 0, pp. 26-35.

Bryceson, D 2002, 'The scramble in Africa: reorienting rural livelihoods', *World Development*, vol. 30, no. 5, pp. 725-739.

Cannon, T and Müller-Mahn, D 2010, 'Vulnerability, resilience and development discourses in context of climate change', *Natural Hazards*, vol. 55, no. 3, pp. 621-635.

Carvalho, A and Burgess, J 2005, 'Cultural circuits of climate change in U.K. Broadsheet newspapers, 1985-2003', *Risk Analysis*, vol. 25, no. 6, pp. 1457-1469.

Challinor, A, Wheeler, T, Garforth, C, Craufurd, P and Kassam, A 2007, 'Assessing the vulnerability of food crop systems in Africa to climate change', *Climatic Change*, vol. 83, no. 3, pp. 381-399.

Chamberlin, J and Schmidt, E 2011, *Ethiopian agriculture: a dynamic geographic perspective*, International Food Policy Research Institute, Washington DC.

Clarke, A 2009, 'Adaptation, poverty and well-being: some issues and observations with special reference to the capability approach and development studies', *Journal of Human Development and Capabilities*, vol. 10, no. 1, p. 22.

Cochran, WG 1977, *Sampling Techniques*, vol. 3rd, 428 vols., Wiley Publication in Applied Statistics, John Wiley & Sons, New York, USA.

Conway, D and Schipper, L 2011, 'Adaptation to climate change in Africa: challenges and opportunities identified from Ethiopia', *Global Environmental Change*, vol. 21, no. 1, pp. 227-237.

Cooper, P, Dimes, J, Rao, K, Shapiro, B, Shiferaw, B and Twomlow, S 2008, 'Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa: an essential first step in adapting to future climate change?', *Agriculture, Ecosystems & Environment*, vol. 126, no. 1, pp. 24-35.

Coppock, DL, Gebru, G, Desta, S, Mesele, S and Tezerra, S 2008, *Are Cattle Die-Offs Predictable on the Borana Plateau*, Utah State University, USA.

Coppock, LD 1994, *The Borana plateau of southern Ethiopia: Synthesis of pastoral research, development and change, 1980-91*, International Livestock Center for Africa (ILCA), Addis Ababa, Ethiopia.

Cox, DR 1989, *The Analysis of Binary Data*, vol. 32, CRC Press, Boca Raton, USA.

Crona, B, Wutich, A, Brewis, A and Gartin, M 2013, 'Perceptions of climate change: linking local and global perceptions through a cultural knowledge approach', *Climatic Change*, vol. 119, no. 2, pp. 519-531.

CSA 2011, *Ethiopian population census survey*, Central Statistical Authority(CSA), Federal Democratic Republic of Ethiopia, Addis Ababa, Ethiopia.

Davies, J and Bennett, R 2007, 'Livelihood adaptation to risk: Constraints and opportunities for pastoral development in Ethiopia's Afar region', *The Journal of Development Studies*, vol. 43, no. 3, pp. 490-511.

Davies, J, Niamir-Fuller, M and Kerven, C 2010, 'Extensive livestock production in transition', in H Steinfeld, H Mooney, F Schneider and L Neville (eds), *Livestock in a changing landscape: Drivers, consequences and responses*, Island Press, Washington Dc, USA, pp. 285-308.

Debela, N, Mohammed, C, Bridle, K, Corkrey, K and McNeil, D 2015, 'Perception of climate change and its impact by smallholders in pastoral/agropastoral systems of Borana, south Ethiopia', *SpringerPlus*, vol. 4, no. 236, pp. 1-12.

Deressa, T 2010, 'Assessment of vulnerability of Ethiopian agriculture to climate change and farmers' adaptation strategies', Doctor of Philosophy thesis, University of Pretoria.

Deressa, T, Hassan, M and Ringler, C 2011, 'Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia', *Journal of Agricultural Science*, vol. 149, no. 1, pp. 23-31.

Deressa, T, Hassan, R, Ringler, C, Alemu, T and Yesuf, M 2009, 'Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia', *Global Environmental Change*, vol. 19, no. 2, pp. 248-255.

Deressa, T, Ringler, C and Hassan, R 2010, *Factors affecting the choices of coping strategies for climate extremes: the case of farmers in the Nile basin of Ethiopia*, Department of Agricultural Economics and Rural Development, University of Pretoria, Pretoria, South Africa.

Desta, S and Coppock, DL 2004, 'Pastoralism under pressure: Tracking system change in Southern Ethiopia', *Human Ecology*, vol. 32, no. 4, pp. 465-486.

Di Falco, S, Veronesi, M and Yesuf, M 2011, 'Does adaptation to climate change provide food security? A micro-perspective from Ethiopia', *American Journal of Agricultural Economics*, vol. 93, no. 3, pp. 825-842.

Di Falco, S, Yesuf, M, Kohlin, G and Ringler, C 2012, 'Estimating the impact of climate change on agriculture in low-income countries: Household level evidence from the Nile Basin, Ethiopia', *Environmental and Resource Economics*, vol. 52, no. 4, pp. 457-478.

Dong, S, Wen, L, Liu, S, Zhang, X, Lassoie, P, Yi, S, Li, X, Li, J and Li, Y 2011, 'Vulnerability of worldwide pastoralism to global changes and interdisciplinary strategies for sustainable pastoralism', *Ecology & Society*, vol. 16, no. 2.

Doria, F, Boyd, E, Tompkins, L and Adger, N 2009, 'Using expert elicitation to define successful adaptation to climate change', *Environmental Science abd Policy*, vol. 12, no. 7, pp. 810-819.

Dovers, SR and Hezri, AA 2010, 'Institutions and policy processes: the means to the ends of adaptation', *Climate Change*, vol. 1, no. 2, pp. 212-231.

Downing, TE 1997, 'Adapting to climate change in Africa', *Mitigation and Adaptation Strategies for Global Change*, vol. 2, no. 1, pp. 19-44.

Driscoll, DL, Appiah-Yeboah, A, Salib, P and Rupert, DJ 2007, 'Merging qualitative and quantitative data in mixed methods research: How to and why not', *Ecological and Environmental Anthropology (University of Georgia)*, vol. 3, no. 1, p. 18.

Eakin, H 2005, 'Institutional change, climate risk, and rural vulnerability: Cases from Central Mexico', *World Development*, vol. 33, no. 11, pp. 1923-1938.

Eakin, H and Luers, L 2006, 'Assessing the vulnerability of social-environmental systems', *Annual Review of Environment and Resources*, vol. 31, pp. 365-394.

Eneyew, A 2012, 'Determinants of livelihood diversification in pastoral societies of southern Ethiopia', *Journal of Agriculture and Biodiversity Research*, vol. 1, no. 3, p. 10.

EPaRDA 2009, *Oromiya National Regional State - Pastoral and agro pastoral livelihood base line profile*, Ethiopian Pastoralist Research and Development Association (EPaRDA), Addis Ababa, Ethiopia.

Eriksen, S, Aldunce, P, Bahinipati, C, Martins, R, Molefe, J, Nhemachena, C, O'brien, K, Olorunfemi, F, Park, J and Sygna, L 2011, 'When not every response to climate change is a good one: Identifying principles for sustainable adaptation', *Climate and Development*, vol. 3, no. 1, pp. 7-20.

Esham, M and Garforth, C 2013, 'Agricultural adaptation to climate change: insights from a farming community in Sri Lanka', *Mitigation and Adaptation Strategies for Global Change*, vol. 18, no. 5, pp. 535-549.

FAO 2006, *Country Pasture/Forage Resource Profiles*, UN FAO, Rome, Italy.

FDRE 2011, *Ethiopia's Climate-Resilient Green Economy*, Federal Democratic Republic of Ethiopia (FDRE), Addis Ababa, Ethiopia.

Ferede, T, Ayenew, A and Hanjra, M 2013, 'Agroecology matters: impacts of climate change on agriculture and its implications for food security in Ethiopia', in LT Cacioppo (eds), *Environmental and Agricultural Research Summaries. Volume 4*, Nova Publishers, Hauppauge, New York, vol. 4, pp. 71-112.

Fratkin, E 2014, 'Ethiopia's pastoralist policies: development, displacement and resettlement', *Nomadic Peoples*, vol. 18, no. 1, pp. 94-114.
Fussel, H 2007a, 'Adaptation planning for climate change: concepts, assessment approaches, and key lessons', *Sustainability Science*, vol. 2, no. 2, pp. 265-275.
Fussel, H 2007b, 'Vulnerability: a generally applicable conceptual framework for climate change research', *Global Environmental Change*, vol. 17, no. 2, pp. 155-167.
Fussel, H and Klein, R 2006, 'Climate change vulnerability assessments: An evolution of conceptual thinking', *Climatic Change*, vol. 75, no. 3, pp. 301-329.
Galvin, A 2001, 'Impacts of climate variability on East African pastoralists: Linking social science and remote sensing', *Climate Research*, vol. 19, no. 2, p. 161.
—— 2009, 'Transitions: Pastoralists living with change', *Annual Review of Anthropology*, vol. 38, pp. 185-198.
Galvin, A, Eriksen, S and Lind, J 2009, 'Adaptation as a political process: adjusting to drought and conflict in Kenya's drylands', *Environmental Management*, vol. 43, no. 5, pp. 817-835.
Gandure, S, Walker, S and Botha, JJ 2013, 'Farmers' perceptions of adaptation to climate change and water stress in a South African rural community', *Environmental Development*, vol. 5, no. 0, pp. 39-53.
Gbetibouo, G 2009, *Understanding farmers' perceptions and adaptations to climate change and variability: The case of the Limpopo basin, South Africa*, International Food Policy Research Institute (IFPRI), Washington DC.
Gbetibouo, G, Hassan, R and Ringler, C 2010, 'Modelling farmers' adaptation strategies for climate change and variability: The case of the Limpopo basin, South Africa', *Agrekon*, vol. 49, no. 2, pp. 217-234.
Gebre-Selassie, A and Bekele, T 2011, *A review of Ethiopian agriculture: roles, policy and small-scale farming systems*, Global Growing, Vienna, Austria.
Gebrehiwot, T and Veen, A 2013, 'Farm level adaptation to climate change: the case of farmer's in the Ethiopian highlands', *Environmental Management*, vol. 52, no. 1, pp. 29-44.
Gebremedhin, B, Jaleta, M and Hoekstra, D 2009, 'Smallholders, institutional services, and commercial transformation in Ethiopia', *Agricultural Economics*, vol. 40, pp. 773-787.
Gilovich, T, Griffin, D and Kahneman, D 2002, *Heuristics and biases: The psychology of intuitive judgment*, Cambridge University Press, Cambridge, United Kingdom.
Gómez-Baggethun, E, Reyes-García, V, Olsson, P and Montes, C 2012, 'Traditional ecological knowledge and community resilience to environmental extremes: A case study in Doñana, SW Spain', *Global Environmental Change*, vol. 22, no. 3, pp. 640-650.

Gorfu, D and Ahmed, E 2011, *Crops and agro-ecological zones of Ethiopia*, Ethiopian Institute of Agricultural Research (EIAR), Addis Ababa, Ethiopia.

Green, D and Raygorodetsky, G 2010, 'Indigenous knowledge of a changing climate', *Climatic Change*, vol. 100, no. 2, pp. 239-242.

Grothmann, T and Patt, A 2005, 'Adaptive capacity and human cognition: The process of individual adaptation to climate change', *Global Environmental Change*, vol. 15, no. 3, pp. 199-213.

Grothmann, T and Reusswig, F 2006, 'People at risk of flooding: why some residents take precautionary action while others do not', *Natural Hazards*, vol. 38, no. 1-2, pp. 101-120.

Haddad, BM 2005, 'Ranking the adaptive capacity of nations to climate change when socio-political goals are explicit', *Global Environmental Change*, vol. 15, no. 2, pp. 165-176.

Hallegatte, S 2009, 'Strategies to adapt to an uncertain climate change', *Global Environmental Change*, vol. 19, no. 2, pp. 240-247.

Hamilton, L 2009, 'Regional variation in perceptions about climate change', *International Journal of Climatology*, vol. 29, no. 15, pp. 2348-2352.

Hansen, J, Sato, M and Ruedy, R 2012, 'Perception of climate change', *PNAS*, vol. 109, no. 37, pp. 2415-2423.

Harley, M, Horrocks, L, Hodgson, N and Minnen, J 2008, *Climate change vulnerability and adaptation indicators*, The European Topic Centre on Air and Climate Change.

Hassan, R and Nhemachena, C 2008, 'Determinants of African farmers' strategies for adapting to climate change: Multinomial choice analysis', *African Journal of Agricultural and Resource Economics*, vol. 2 (1), p. 22.

Heyd, T and Brooks, N 2009, 'Exploring cultural dimensions of adaptation to climate change', in W Adger, I Lorenzoni and K O'Brien (eds), *Adapting to climate change: Thresholds, values, governance*, Cambridge University Press, Cambridge, UK, pp. 269-282.

Homann, S 2004, 'Indigenous knowledge of Borana pastoralists in natural resource management: A case study from southern Ethiopia', Doctor of Philosophy thesis, Justus Liebig University Giessen, Germany.

Homann, S, Rischkowsky, B and Steinbach, J 2008a, 'The effect of development interventions on the use of indigenous range management strategies in the Borana lowlands in Ethiopia', *Land Degradation & Development*, vol. 19, no. 4, pp. 368-387.

Homann, S, Rischkowsky, B, Steinbach, J, Kirk, M and Mathias, E 2008b, 'Towards endogenous livestock development: Borana pastoralists' responses to environmental and institutional changes', *Human Ecology*, vol. 36, no. 4, pp. 503-520.

Howden, M, Soussana, J-F, Tubiello, FN, Chhetri, N, Dunlop, M and Meinke, H 2007, 'Adapting agriculture to climate change', *PNAS*, vol. 104, no. 50, pp. 19691-19696.

Huho, J, Ngaira, J and Ogind, H 2011, 'Living with drought: the case of the Maasai pastoralists of northern Kenya', *Educational Research*, vol. 2, no. 1, pp. 779-789.

Hurni, H 1998, *Agroecological belts of Ethiopia: Explanatory notes on three maps at a scale of 1:1,000,000*, Centre for Development and Environment, University of Bern, Addis Ababa.

Hurst, M, Jensen, N, Pedersen, S, Sharma, A and Zambriski, J 2012, *Changing climate adaptation strategies of Boran pastoralists in southern Ethiopia*, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Copenhagen, Denmark.

IBM Corp 2012, *IBM SPSS Statistics for Windows, Version 21.0*, IBM Corp., Armonk, NY.

Iglesias, A, Mougou, R, Moneo, M and Quiroga, S 2011, 'Towards adaptation of agriculture to climate change in the Mediterranean', *Regional Environmental Change*, vol. 11, no. SUPPL. 1, pp. 159-166.

IPCC 2012, *Managing the risks of extreme events and disasters to advance climate change cdaptation: a special report of working groups I and II of the Intergovernmental Panel on Climate Change*, 1107025060, Cambridge University Press, Cambridge and New York, NY, USA, Geneva, Switzerland.

—— 2013, 'Regional report on Africa', in P Dube and N Leary (eds), *Climate change 2013: Impacts, adaptation, and vulnerability*, Geneva, Switzerland.

—— 2014, *Climate change 2014: Impacts, adaptation, and vulnerability*, Intergovernmental Panel on Climate Change (IPCC), Geneva, Switzerland.

Johnson, B and Onwuegbuzie, J 2004, 'Mixed methods research: A research paradigm whose time has come', *Educational Researcher*, vol. 33, no. 7, pp. 14-26.

Jones, L and Boyd, E 2011, 'Exploring social barriers to adaptation: Insights from Western Nepal', *Global Environmental Change*, vol. 21, pp. 1262-1274.

Jones, P and Thornton, P 2009, 'Croppers to livestock keepers: livelihood transitions to 2050 in Africa due to climate change', *Environmental Science & Policy*, vol. 12, no. 4, pp. 427-437.

Juana, J, Kahaka, Z and Okurut, F 2013, 'Farmers' perceptions and adaptations to climate change in sub-Sahara Africa: a synthesis of empirical studies and implications for public policy in African agriculture', *Journal of Agricultural Science*, vol. 5, no. 4, pp. 121-135.

Kahan, M, Jenkins, S and Braman, D 2010, 'Cultural cognition of scientific consensus', *Journal of Risk Research*, vol. 14, no. 2, pp. 147-174.

Kalungu, J, Leal Filho, W and Harris, D 2013, 'Smallholder farmers' perception of the impacts of climate change and variability on rain-fed agricultural practices in semi-arid and

sub-humid regions of Kenya', *Journal of Environment and Earth Science*, vol. 3, no. 7, pp. 129-140.

Kamara, AB, Swallow, B and Kirk, M 2004, 'Policies, interventions and institutional change in pastoral resource management in Borana, Southern Ethiopia', *Development Policy Review*, vol. 22, no. 4, pp. 381-403.

Kassie, M, Zikhali, P, Pender, J and Köhlin, G 2009, *Sustainable agricultural practices and agricultural productivity in Ethiopia: Does agroecology matter?*, Environment for Development, Gothenberg, Sweden.

Kates, RW, Travis, WR and Wilbanks, TJ 2012, 'Transformational adaptation when incremental adaptations to climate change are insufficient', *Proceedings of the National Academy of Sciences*, vol. 109, no. 19, pp. 7156-7161.

Kelly, M and Adger, N 2000, 'Theory and practice in assessing vulnerability to climate change and facilitating adaptation', *Climatic Change*, vol. 47, no. 4, pp. 325-352.

Kelly, M and Eriksen, H 2007, 'Developing credible vulnerability indicators for climate adaptation policy assessment', *Mitigation and Adaptation Strategies for Global Change*, vol. 12, no. 4, pp. 495-524.

Kemausuor, F, Dwamena, E, Bart-Plange, A and Kyei-Baffour, N 2011, 'Farmers' perception of climate change in the Ejura-Sekyedumase district of Ghana', *ARPN Journal of Agricultural and Biological Science*, vol. 6, no. 10, pp. 25-37.

Klein, R, Midgley, G, Preston, B, Alam, M, Berkhout, F, Dow, K and Shaw, R 2014, 'Adaptation opportunities, constraints, and limits', in IPCC (eds), *Climate Change 2014: Impacts, Adaptation and Vulnerability*, Intergovernmental Panel on Climate Change (IPCC), Switzerland, p. 51.

Kolstad, C, Kelly, D and Mitchell, G 1999, *Adjustment costs from environmental change induced by incomplete information and learning*, 10-99, Department of Economics, University of California, Santa Barbara, CA.

Köppen, W 1918, 'Klassifikation der Klimate nach Temperatur, Niederschlag und Jahreslauf', *Petermanns Geogr. Mitteilungen*, pp. 25-35.

Kurukulasuriya, P, Mendelsohn, R, Hassan, R, Benhin, J, Deressa, T, Diop, M, Eid, M, Fosu, Y, Gbetibouo, G, Jain, S, Mahamadou, A, Mano, R, Kabubo-Mariara, J, El-Marsafawy, S, Molua, E, Ouda, S, Ouedraogo, M, Sene, I, Maddison, D, Seo, SN and Dinar, A 2006, 'Will African agriculture survive climate change?', *The World Bank Economic Review*, vol. 20, no. 3, pp. 367-388.

Lavers, T 2012, 'Patterns of agrarian transformation in Ethiopia: State-mediated commercialisation and the 'land grab'', *The Journal of Peasant Studies*, vol. 39, no. 3-4, pp. 795-822.

Legesse, A 1973, *Gada: Three approaches to the study of African society*, Free Press New York.

Leichenko, M and O'Brien, L 2002, 'The dynamics of rural vulnerability to global change: The case of southern Africa', *Mitigation and Adaptation Strategies for Global Change*, vol. 7, no. 1, pp. 1-18.

Leiserowitz, A 2006, 'Climate change risk perception and policy preferences: the role of affect, imagery, and values', *Climatic Change*, vol. 77, no. 1-2, pp. 45-72.

Lesnoff, M, Corniaux, C and Hiernaux, P 2012, 'Sensitivity analysis of the recovery dynamics of a cattle population following drought in the Sahel region', *Ecological Modelling*, vol. 232, pp. 28-39.

Ligon, E and Schechter, L 2003, 'Measuring vulnerability', *The Economic Journal*, vol. 113, no. 486, pp. 95-102.

Little, PD, Behnke, R, McPeak, J and Gebru, G 2010, *Retrospective assessment of pastoral policies in Ethiopia, 1991-2008*, 1, Department for International Development (DFID), Addis Ababa, Ethiopia, March 2010.

Lorenzoni, I, Nicholson-Cole, S and Whitmarsh, L 2007, 'Barriers perceived to engaging with climate change among the UK public and their policy implications', *Global Environmental Change*, vol. 17, no. 3-4, pp. 445-459.

Lowe, T 2006, *Vicarious experience vs scientific information in climate change risk perception and behaviour: a case study of undergraduate students in Norwich, UK*, University of East Anglia, Tyndall Centre for Climate Change Research, Norwich, UK.

Luers, A, Lobell, D, Sklar, L, Addams, C and Matson, P 2003, 'A method for quantifying vulnerability, applied to the agricultural system of the Yaqui Valley, Mexico', *Global Environmental Change*, vol. 13, p. 13.

Luseno, WK, McPeak, JG, Barrett, CB, Little, PD and Gebru, G 2003, 'Assessing the value of climate forecast information for pastoralists: Evidence from Southern Ethiopia and Northern Kenya', *World Development*, vol. 31, no. 9, pp. 1477-1494.

Maddison, D 2007, *The perception of and adaptation to climate change in Africa*, 4308, The World Bank, Washington D.C., USA, August 2007.

Mahrenholz, P 2008, 'Climate change and adaptation needs', *Parasitology Research*, vol. 103, no. 1, pp. 139-146.

Makepe, PM 2006, 'The evolution of institutions and rules governing communal grazing lands in Botswana', *Eastern Africa social science research review*, vol. 22, no. 1, pp. 39-61.

Mapfumo, P, Adjei-Nsiah, S, Mtambanengwe, F, Chikowo, R and Giller, KE 2013, 'Participatory action research (PAR) as an entry point for supporting climate change adaptation by smallholder farmers in Africa', *Environmental Development*, vol. 5, no. 0, pp. 6-22.

McDowell, Z and Hess, J 2012, 'Accessing adaptation: Multiple stressors on livelihoods in the Bolivian highlands under a changing climate', *Global Environmental Change*, vol. 22, no. 2, pp. 342-352.

McIntosh, C, Sarris, A and Papadopoulos, F 2013, 'Productivity, credit, risk, and the demand for weather index insurance in smallholder agriculture in Ethiopia', *Agricultural Economics*, vol. 44, pp. 399-417.

McSweeney, C, New, M and Lizcano, G 2008, *UNDP Climate Change Country Profiles - Ethiopia*, United Nations Development Program, Addis ababa, Ethiopia.

Megersa, B, Markemann, A, Angassa, A and Zárate, AV 2013, 'The role of livestock diversification in ensuring household food security under a changing climate in Borana, Ethiopia', *Food Security*, pp. 1-14.

Meinke, H, Nelson, R, Kokic, P, Stone, R, Selvaraju, R and Baethgen, W 2006, 'Actionable climate knowledge: from analysis to synthesis', *Climate Research*, vol. 33 pp. 101-110.

Melillo, J, Callaghan, T, Woodward, F, Salati, E and Sinha, S 1990, 'Effects on ecosystems', in T Houghton, J Jenkins and J Ephraums (eds), *Climate Change: The IPCC Scientific Assessment*, Cambridge University Press, New York, USA, pp. 287-310, via cat02831a (EBSCOhost).

Mertz, O, HalsnAs, K, Olesen, J and Rasmussen, K 2009a, 'Adaptation to climate change in developing countries', *Environmental Management*, vol. 43, no. 5, pp. 743-752.

Mertz, O, Mbow, C, Reenberg, A and Diouf, A 2009b, 'Farmers' perceptions of climate change and agricultural adaptation strategies in rural sahel', *Environmental Management*, vol. 43, no. 5, pp. 804-816.

Mideksa, TK 2010, 'Economic and distributional impacts of climate change: the case of Ethiopia', *Global Environmental Change*, vol. 20, no. 2, pp. 278-286.

MoA 2011, *Agriculture sector programme of plan on adaptation to climate change*, Ministry of Agriculture, Federal Democratic Republic of Ethiopia (FDRE), Addis Ababa, Ethiopia.

MoARD 2005, *Agroecological zonations of Ethiopia*, Ministry of Agriculture (MoA), Federal Democratic Republic of Ethiopia (FDRE), Addis Ababa, Ethiopia.

Moser, SC and Ekstrom, JA 2010, 'A framework to diagnose barriers to climate change adaptation', *PNAS*, vol. 107, no. 51, pp. 22026-22031.

Mueller, C, Cramer, W, Hare, WL and Lotze-Campen, H 2011, 'Climate change risks for African agriculture', *Proceedings of the National Academy of Sciences of the United States of America*, vol. 108, no. 11, pp. 4313-4315.

Muller-Mahn, D, Rettberg, S and Getachew, G 2010, 'Pathways and dead ends of pastoral development among the Afar and Karrayu in Ethiopia', *European Journal of Development Research*, vol. 22, pp. 660-677.

Mustapha, SB, Sanda, AH and Shehu, H 2012, 'Farmers' perception of climate change in central agricultural zone of Borno state, Nigeria.', *Journal of Environment and Earth Science*, vol. 2, no. 11, pp. 21-28.

Ndambiri, HK, Ritho, C, Mbogoh, SG, Ng'ang'a, SI, Muiruri, EJ, Nyangweso, PM, Kipsat, MJ, Omboto, PI, Ogada, JO, Kefa, C, Kubowon, PC and Cherotwo, FH 2012, 'Analysis of farmers' perceptions of the effects of climate change in Kenya: the case of Kyuso district', *Journal of Environment and Earth Science*, vol. 2, no. 10, pp. 74-83.

Ng, R and Rayner, S 2010, 'Integrating psychometric and cultural theory approaches to formulate an alternative measure of risk perception', *Innovation: The European Journal of Social Science Research*, vol. 23, no. 2, pp. 85-100.

Nielsen, J and Reenberg, A 2010, 'Cultural barriers to climate change adaptation: A case study from Northern Burkina Faso', *Global Environmental Change*, vol. 20, no. 1, pp. 142-152.

NMSA 2001, *Initial national communication of Ethiopia to the United Nations Framework Convention on Climate Change*, National Meteorological Services Agency (NMSA), Addis Ababa, Ethiopia.

Noble, I, Huq, S, Anokhin, Y, Carmin, J, Goudou, D, Lansigan, F, Osman-Elasha, B and Villamizar, A 2014, 'Adaptation needs and options', in C Field, V Barros, D Dokken, K Mach, M Mastrandrea, T Bilir, M Chatterjee, K Ebi, Y Estrada, R Genova, B Girma, K Kissel, A Levy, S MacCracken, P Mastrandrea and L White (eds), *Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Intergovernmental Panel on Climate Change (IPCC), Switzerland, vol. Assesment Report 5, p. 51.

Nyanga, PH, Johnsen, FH, Aune, JB and Kalinda, TH 2011, 'Smallholder farmers' perceptions of climate change and conservation agriculture: evidence from Zambia', *Journal of Sustainable Development*, vol. 4, no. 4, pp. 73-85.

Nyong, A, Adesina, F and Elasha, BO 2007, 'The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel', *Mitigation and Adaptation Strategies for Global Change*, vol. 12, no. 5, pp. 787-797.

O'Brien, K, Eriksen, S, Nygaard, LP and Schjolden, E 2007, 'Why different interpretations of vulnerability matter in climate change discourses', *Climate Policy*, vol. 7, no. 1, pp. 73-88.

O'Brien, K, Eriksen, S, Sygna, L and Naess, LO 2006, 'Questioning complacency: Climate change impacts, vulnerability, and adaptation in Norway', *Ambio*, vol. 35, no. 2, pp. 50-56.

O'Riordan, T and Jordan, A 1999, 'Institutions, climate change and cultural theory: towards a common analytical framework', *Global Environmental Change*, vol. 9, no. 2, pp. 81-93.

OECD 2014, *Climate resilience in development planning experiences in Colombia and Ethiopia: Experiences in Colombia and Ethiopia*, OECD Publishing, Paris, France.

ONRS 2009, *Oromiya livelihood zone reports - Borena administrative Zone*, Oromia National Regional State, Addis Ababa, Ethiopia.

Osbahr, H, Dorward, P, Stern, R and Cooper, S 2011, 'Supporting agricultural innovation in Uganda to respond to climate risk: linking climate change and variability with farmer perceptions', *Experimental Agriculture*, vol. 47, no. 02, pp. 293-316.

Osbahr, H, Twyman, C, Adger, N and Thomas, D 2010, 'Evaluating successful livelihood adaptation to climate variability and change in Southern Africa', *Ecology & Society*, vol. 15, no. 2.

Ostrom, E 1990, *Governing the commons: The evolution of institutions for collective action*, Cambridge University Press, Cambridge, UK.

Ostrom, E and Basurto, X 2010, 'Crafting analytical tools to study institutional change', *Journal of Institutional Economics*, vol. 7, no. Special Issue 03, pp. 317-343.

Patt, A and Schröter, D 2008, 'Perceptions of climate risk in Mozambique: implications for the success of adaptation strategies', *Global Environmental Change*, vol. 18, no. 3, pp. 458-467.

Patt, A, Suarez, P and Hess, U 2010, 'How do small-holder farmers understand insurance, and how much do they want it? Evidence from Africa', *Global Environmental Change*, vol. 20, no. 1, pp. 153-161.

Pauw, P 2013, 'The role of perception in subsistence farmer adaptation in Africa-enriching the climate finance debate', *International Journal of Climate Change Strategies and Management*, vol. 5, no. 3, pp. 3-3.

Pelling, M 2011, *Adaptation to climate change: from resilience to transformation.*, Routledge Taylor and Francis Group, London, UK.

Polanyi, M 1966, *The tacit dimension*, Doubleday, Garden City, N.Y.

Polson, RA and Spencer, DSC 1991, 'The technology adoption process in subsistence agriculture: The case of cassava in Southwestern Nigeria', *Agricultural Systems*, vol. 36, no. 1, pp. 65-78.

QSR International 2012, *NVivo qualitative data analysis software - QSR International Pty Ltd. Version 10, 2012*, Melbourne, Australia.

Ranganathan, C, Palanisami, K, Kakumanu, K and Baulraj, A 2010, *Mainstreaming the adaptations and reducing the vulnerability of the poor due to climate change* Asian Development Bank Institute, Tokyo, Japan.

Ratter, B, Philipp, K and von Storch, H 2012, 'Between hype and decline: recent trends in public perception of climate change', *Environmental Science & Policy*, vol. 18, pp. 3-8.

Raymond, C and Robinson, GM 2013, 'Factors affecting rural landholders' adaptation to climate change: Insights from formal institutions and communities of practice', *Global Environmental Change*, vol. 23, no. 1, pp. 103-114.

Reidsma, P 2007, 'Adaptation to climate change: European agriculture', Doctor of Philosophy thesis, Wageningen University, The Netherlands.

Riché, B, Hachileka, E, Awuor, CB and Hammill, A 2009, *Climate related vulnerability and adaptive capacity in Ethiopia's Borana and Somali communities*, Save the Children UK.

Rickards, L and Howden, S 2012, 'Transformational adaptation: agriculture and climate change', *Crop and Pasture Science*, vol. 63, no. 3, pp. 240-250.

Riddle, E and Cook, H 2008, 'Abrupt rainfall transitions over the Greater Horn of Africa: Observations and regional model simulations', *Journal of Geophysical Research D: Atmospheres*, vol. 113, no. 15.

Risbey, J, Kandlikar, M, Dowlatabadi, H and Graetz, D 1999, 'Scale, context, and decision making in agricultural adaptation to climate variability and change', *Mitigation and Adaptation Strategies for Global Change*, vol. 4, no. 2, pp. 137-165.

Robinson, S, Willenbockel, D and Strzepek, K 2012, 'A dynamic general equilibrium analysis of adaptation to climate change in Ethiopia', *Review of Development Economics*, vol. 16, no. 3, pp. 489-502.

Roco, L, Engler, A, Bravo-Ureta, B and Jara-Rojas, R 2014, 'Farmers' perception of climate change in Mediterranean Chile', *Regional Environmental Change*, vol. 15, pp. 1-13.

Rodima, D, Olwig, M and Chhetri, N 2012, 'Adaptation as innovation, innovation as adaptation: An institutional approach to climate change', *Applied Geography*, vol. 33, pp. 107-111.

Ruddell, D, Harlan, S, Grossman-Clarke, S and Chowell, G 2012, 'Scales of perception: public awareness of regional and neighborhood climates', *Climatic Change*, vol. 111, no. 3-4, pp. 581-607.

Rufino, C, Thornton, P, Ng'ang'a, K, Mutie, I, Jones, P, van Wijk, T and Herrero, M 2013, 'Transitions in agropastoralist systems of East Africa: Impacts on food security and poverty', *Agriculture, Ecosystems & Environment*, vol. 179, pp. 215-230.

Sampei, Y and Aoyagi-Usui, M 2009, 'Mass-media coverage, its influence on public awareness of climate-change issues, and implications for Japan's national campaign to reduce greenhouse gas emissions', *Global Environmental Change*, vol. 19, no. 2, pp. 203-212.

SAS Institute 2000, *SAS Version 9.2*, SAS Institute Inc, North Carolina, United States.

Scheraga, D 1998, 'Risks, opportunities and adaptation to climate change', *Climate Research*, vol. 11, no. 1, p. 85.

Schlenker, W and Lobell, B 2010, 'Robust negative impacts of climate change on African agriculture', *Environmental Research Letters*, vol. 5, no. 1.

Seleshi, Y and Zanke, U 2004, 'Recent changes in rainfall and rainy days in Ethiopia', *International Journal of Climatology*, vol. 24, no. 8, pp. 973-983.

Semenza, JC, Hall, DE, Wilson, DJ, Bontempo, BD, Sailor, DJ and George, LA 2008, 'Public perception of climate change: voluntary mitigation and barriers to behavior change', *American Journal of Preventive Medicine*, vol. 35, no. 5.

Shiferaw, B, Muricho, G and Hellin, J 2011, 'Improving market access and agricultural productivity growth in Africa: What role for producer organizations and collective action institutions?', *Food Security*, vol. 3, no. 4, pp. 475-489.

Silvestri, S, Bryan, E, Ringler, C, Herrero, M and Okoba, B 2012, 'Climate change perception and adaptation of agropastoral communities in Kenya', *Regional Environmental Change*, vol. 12, no. 4, pp. 791-802.

Sjöberg, L 2000a, 'Factors in risk perception', *Risk Analysis*, vol. 20, pp. 1-11.

—— 2000b, 'The methodology of risk perception research', *Quality and Quantity*, vol. 34, no. 4, pp. 407-418.

Smit, B, Burton, I, Klein, R and Street, R 1999, 'The science of adaptation: a framework for assessment', *Mitigation and Adaptation Strategies for Global Change*, vol. 4, pp. 199–213.

Smit, B, Burton, I, Klein, R and Wandel, J 2000, 'An anatomy of adaptation to climate change and variability', *Climate Change*, vol. 45, pp. 223-251.

Smit, B and Skinner, M 2002, 'Adaptation options in agriculture to climate change: a typology', *Mitigation and Adaptation Strategies for Global Change*, vol. 7, no. 1, pp. 85-114.

Smithers, J and Smit, B 1997, 'Human adaptation to climatic variability and change', *Global Environmental Change*, vol. 7, no. 2, pp. 129-146.

Smiths, J, Smit, B, Ilbery, B and Chiotti, Q 1997, *Agricultural system responses to environmental stress*, Agricultural Restructuring and Sustainability: A geographical perspective, CAB International, Wallingford, UK.

Soares, M, Gagnon, S and Doherty, M 2012, 'Conceptual elements of climate change vulnerability assessments: a review', *International Journal of Climate Change Strategies and Management*, vol. 4, no. 1, pp. 6-35.

Solomon, B, Snyman, A and Smit, N 2007, 'Cattle-rangeland management practices and perceptions of pastoralists towards rangeland degradation in the Borana zone of southern Ethiopia', *Journal of Environmental Management*, vol. 82, no. 4, pp. 481-494.

Speranza, I, Kiteme, B, Ambenje, P, Wiesmann, U and Makali, S 2010, 'Indigenous knowledge related to climate variability and change: Insights from droughts in semi-arid areas of former Makueni District, Kenya', *Climatic Change*, vol. 100, no. 2, pp. 295-315.

Stadelmann, M, Michaelowa, A, Butzengeiger-Geyer, S and Köhler, M 2011, 'Universal metrics to compare the effectiveness of climate change adaptation projects', p. 28.

Stokes, M, Davis, C and Koch, G 2000, *Categorical data analysis using the SAS system*, John Wiley & Sons Inc, Cary, NC, USA.

Tache, B 2008, 'Pastoralism under stress: resources, institutions and poverty among the Borana Oromo in southern Ethiopia', Doctor of Philosophy thesis, Norwegian University of Life Sciences, Ås, Norway.

Tache, B and Irwin, B 2003, *Traditional institutions, multiple stakeholders and modern perspectives in common property: accompanying change within Borana pastoral systems*, SOS Sahel International, London, United Kingdom.

Tache, B and Oba, G 2010, 'Is poverty driving Borana herders in southern Ethiopia to crop cultivation?', *Human Ecology*, vol. 38, pp. 639-649.

Tache, B and Sjaastad, E 2010, 'Pastoralists' conceptions of poverty: an analysis of traditional and conventional indicators from Borana, Ethiopia', *World Development*, vol. 38, no. 8, pp. 1168-1178.

Tambo, J and Abdoulaye, T 2013, 'Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian savanna', *Regional Environmental Change*, vol. 13, no. 2, pp. 375-388.

Teka, O, Houessou, GL, Oumorou, M, Vogt, J and Sinsin, B 2013, 'An assessment of climate variation risks on agricultural production: perceptions and adaptation options in Benin', *International Journal of Climate Change Strategies and Management*, vol. 5, no. 2, pp. 166-180.

Teka, O and Vogt, J 2010, 'Social perception of natural risks by local residents in developing countries - The example of the coastal area of Benin', *The Social Science Journal*, vol. 47, no. 1, pp. 215-224.

Temesgen, D and Rashid, H 2009, 'Economic impact of climate change on crop production in Ethiopia: Evidence from cross-section measures', *Journal of African Economies*, vol. 18, no. 4, pp. 529-554.

Tesemma, ZK, Mohamed, YA and Steenhuis, TS 2010, 'Trends in rainfall and runoff in the Blue Nile Basin: 1964-2003', *Hydrological Processes*, vol. 24, no. 25, pp. 3747-3758.

Thomas, G, Twyman, C, Osbahr, H and Hewitson, B 2007, 'Adaptation to climate change and variability: Farmer responses to intra-seasonal precipitation trends in South Africa', *Climatic Change*, vol. 83, no. 3, pp. 301-322.

Thornthwaite, C 1948, 'An approach toward a rational classification of climate', *Geographical Review*, vol. 38, no. 1, pp. 55-94.

Thornton, P, Boone, R, Galvin, K, Bunsilver, S, Waithaka, M, Kuyiah, J, Karanja, S, Gonzalez-Estrada, E and Herrero, M 2007, 'Coping strategies in livestock-dependent households in East and southern Africa: A synthesis of four case studies', *Human Ecology*, vol. 35, pp. 461-476.

Thornton, P, van de Steeg, J, Notenbaert, A and Herrero, M 2009, 'The impacts of climate change on livestock and livestock systems in developing countries: A review of what we know and what we need to know', *Agricultural Systems*, vol. 101, no. 3, pp. 113-127.

Tilahun, H, Teklu, E, Michael, M, Fitsum, H and Awulachew, B 2011, 'Comparative performance of irrigated and rainfed agriculture in Ethiopia', *World Applied Sciences Journal*, vol. 14, no. 2, pp. 235-244.

Tolera, A and Abebe, A 2007, 'Livestock production in pastoral and agropastoral production systems of southern Ethiopia', *Livestock Research for Rural Development*, vol. 19, no. 12.

Tribbia, J and Moser, SC 2008, 'More than information: what coastal managers need to plan for climate change', *Environmental Science & Policy*, vol. 11, pp. 315-328.

Tsegaye, D, Moe, SR, Vedeld, P and Aynekulu, E 2010, 'Land-use/cover dynamics in Northern Afar rangelands, Ethiopia', *Agriculture, Ecosystems and Environment*, vol. 139, no. 1-2, pp. 174-180.

Tsegaye, D, Vedeld, P and Moe, S 2013, 'Pastoralists and livelihoods: A case study from northern Afar, Ethiopia', *Journal of Arid Environments*, vol. 91, pp. 138-146.

Turner, B, Kasperson, RE, Matson, PA, McCarthy, JJ, Corellg, RW, Christensen, L, Eckley, N, Kasperson, JX, Luers, A, Martello, ML, Polsky, C, Pulsipher, A and Schiller, A 2003, 'A framework for vulnerability analysis in sustainability science', *PNAS*, vol. 100, no. 14, pp. 8074-8079.

Uphoff, N and Buck, L 2006, *Strengthening rural local institutional capacities for sustainable livelihoods and equitable development*, World Bank, Washington DC, USA.

Upton, C 2012, 'Adaptive capacity and institutional evolution in contemporary pastoral societies', *Applied Geography*, vol. 33, pp. 135-141.

van Ginkel, M, Sayer, J, Sinclair, F, Aw-Hassan, A, Bossio, D, Craufurd, P, El Mourid, M, Haddad, N, Hoisington, D and Johnson, N 2013, 'An integrated agro-ecosystem and livelihood systems approach for the poor and vulnerable in dry areas', *Food Security*, vol. 5, no. 6, pp. 751-767.

Virtanen, P, Palmujoki, E and Gemechu, D 2011, 'Global climate policies, local institutions and food security in a pastoral society in Ethiopia', *Consilience: The Journal of Sustainable Development*, vol. 5, no. 1, pp. 96-118.

Wang, J, Brown, DG, Riolo, RL, Page, SE and Agrawal, A 2013, 'Exploratory analyses of local institutions for climate change adaptation in the Mongolian grasslands: An agent-based modeling approach', *Global Environmental Change*, vol. 23, no. 5, pp. 1266-1276.

Warren, F and Lemmen, D 2014, *Canada in a changing climate: Sector perspectives on impacts and adaptation*, Ottawa, canada.

Washington-Ottombre, C and Pijanowski, B 2013, 'Rural organizations and adaptation to climate change and variability in rural Kenya', *Regional Environmental Change*, vol. 13, no. 3, pp. 537-550.

Watson, EE 2003, 'Examining the potential of indigenous institutions for development: a perspective from Borana, Ethiopia', *Development and Change*, vol. 34, no. 2 pp. 287-109.

Weber, E 2010, 'What shapes perceptions of climate change?', *Wiley Interdisciplinary Reviews: Climate Change*, vol. 1, no. 3, pp. 332-342.

Weller, SC 2007, 'Cultural consensus theory: Applications and frequently asked questions', *Field Methods*, vol. 19, no. 4, pp. 339-368.

Whitmarsh, L 2008, 'Are flood victims more concerned about climate change than other people? The role of direct experience in risk perception and behavioural response', *Journal of Risk Research*, vol. 11, no. 3, pp. 351-374.

Wilby, L and Dessai, S 2010, 'Robust adaptation to climate change', *Weather*, vol. 65, no. 7, pp. 180-185.

World Bank 2006, *Managing water resources to maximise sustainable growth: a country water resources assistance strategy for Ethiopia*, World Bank, Washington D.C., USA.

Yami, M, Vogl, C and Hauser, M 2009, 'Comparing the effectiveness of informal and formal institutions in sustainable common pool resources management in Sub-Saharan Africa', *Conservation and Society*, vol. 7, no. 3, p. 153.

Yami, M, Vogl, C and Hauser, M 2011, 'Informal institutions as mechanisms to address challenges in communal grazing land management in Tigray, Ethiopia', *International Journal of Sustainable Development & World Ecology*, vol. 18, no. 1, pp. 78-87.

Yohannes, G 2003, 'Ethiopia in view of the national Adaptation Program of Action. ', *National Meteorological Services Agency, Addis ababa, Ethiopia*.

Yu, H, Wang, B, Zhang, Y-J, Wang, S and Wei, Y-M 2013, 'Public perception of climate change in China: results from the questionnaire survey', *Natural Hazards*, vol. 69, no. 1, pp. 459-472.

Zampaligré, N, Dossa, LH and Schlecht, E 2014, 'Climate change and variability: perception and adaptation strategies of pastoralists and agropastoralists across different zones of Burkina Faso', *Regional Environmental Change*, pp. 1-15.

Zaroug, M, Eltahir, E and Giorgi, F 2014, 'Droughts and floods over the upper catchment of the Blue Nile and their connections to the timing of El Niño and La Niña events', *Hydrology and Earth System Sciences*, vol. 18, pp. 1239-1249.

Ziervogel, G, Cartwright, A, Tas, A, Adejuwon, J, Zermoglio, F, Shale, M and Smith, **B** 2008, *Climate change and adaptation in African agriculture*, Stockholm Environment Institute, Stockholm, Sweden.

Zinyengere, N, Crespo, O and Hachigonta, S 2013, 'Crop response to climate change in southern Africa: A comprehensive review', *Global and Planetary Change*, vol. 111, no. 0, pp. 118-126.

Zuma-Netshiukhwi, G, Stigter, K and Walker, S 2013, 'Use of traditional weather/climate knowledge by farmers in the South-western Free State of South Africa: Agrometeorological learning by scientists', *Atmosphere*, vol. 4, no. 4, pp. 383-410.

Appendixes

Appendix i. A farm household interview questionnaire on perception of and adaptation to climate change

(Perception, Adaptation decisions and Strategies)

Questionnaire I - Interview for Farmers (384 Interviews)

Identification number (code): _____

Date of interview: _____/____/_____

District: _____

Production system: _____

Peasant association: _____

Village (Olla): _____

Note: Hello! My name is _____. I am hoping that I may be able to spend one to one and half hours with you asking you about climate variability/change adaptation in your area. My research aims to assist the region and community by highlighting key issues that need to be addressed by policy makers, researchers and practitioners. Your answers will be confidential and you will be unidentifiable, and I will only present the results in aggregate form. Please don't feel as if you have to answer every question I'm going to ask you. Do you have any questions?

Declaration of Consent

Having listened to the information on the Information Sheet, I confirm my voluntary participation to this interview.

Yes ☐ No ☐ Signature: _____ Date: _____

A. General

1. Gender: 1.Male 2. Female

2. How old are you? _____ (years)

3. What is your marital status? 1.Married 2.Single 3.Divorced 4. Widowed 5.Other,_____

4. What is the highest level of education you have achieved? 1.Religious education 2.Adult education 3.No formal education 4.Formal education (grade _____) 5.College diploma 6.University degree

5. What is your religion? 1.Waqefataa (animist) 2.Muslim 3.Christian Orthodox 4.Christian Protestant 5.Other, specify _____

6. What is your total family size (how many people are in your household)? Total _____ Male ____Female____

7. How many years of farming experience do you have? _____

8. What is the social status of the household head in the PA? 1.Village executive member 2.Group leader 3.Clan leader 4.Religious leader 5.Edir and other social committee member 6.Community elder 7.Other (specify) _____

B. Farm Characteristics and Farming Systems

9. What is the dominant farming system in your area?

1.Crop based 2.Livestock based 3.Mixed crop-livestock systems 4.Others, specify _____

10. What is the total size of your private farm(enclosure and cultivation)? _____ (ha); Cultivated _____ha; Grazing _____ha; Others, _____(ha)

11. Is your farmland fragmented (in more than one adjacent piece)? 1.Yes 2.No

12. If yes, into how many plots? _____

Crop Enterprise

13. Do you cultivate crops? 1.Yes 2.No (Go to Q17)

14. If yes, which type of crops do you mainly grow?

1.Cereals (maize, beans, etc) 2.Pulses 3.Oil crops 4.Horticultural crops 5.Others(specify),___

15. Can you please mention them in order of importance? (Rank 3 of them)

1._____ 2. _____

3._____

16. Which kind of cropping pattern do you often use? 1.Maize-bean-maize, 2.Maize-bean-fallow 3.Others (specify),_____

Livestock Enterprise

17. Do you own livestock? 1.Yes 2.No (Go to Q22)

18. If yes, what are the major livestock types you produce?

1.Cattle 2.Shoats (sheep and goats) 3.Camel 4.Chickens 5.Others, specify _____

19. Can you please tell me the current composition of your livestock herd in type and number?

ox	cow	sheep	goat	donkey	camel	horse	poultry	Total

20. For what purpose(s) do you rear livestock?

1.Its products (milk and meat) 2.Traction power 3.Income generation by selling them 4.Transportation 5.Wealth status/cultural value 6.Others, specify _____

21. What is/are the main feed source(s) for your livestock?

1.Open rangelands 2. Enclosure - Private 3.Enclosure - communal 4.Hay and feed supplements 5.Others, specify _____

22. How are pasturelands owned in your area?

1.Privately 2.Communally 3.Both private and communal 4.Leased/rented 5.Others, specify _____

23. Do you own private pastureland or enclosure? 1. Yes 2. No

24. If yes, how did you acquire it?

1.Bounded myself from the communal land 2.It was my arable land in the past 3.Bought it 4.Leased or rented in from someone else 5.Farm side left 6.Inherited from my parents/grand parents 7.Others, specify _____

25. What has been the trend in overall size of rangeland during the last ten years in your area?

1.Expanding 2.Shrinking 3.No change 4. Not sure

26. If shrinking or expanding, can you state main reason for this trend?

1. Diminishing demand for grazing 2. Better management of grazing land 3.Good climatic conditions 4.Expansion of cultivated land 5.Bush encroachment 6.Land degradation 7.Afforestation/Reforestation 8.Expansion of settlement 9. Rising human population 10.Rising livestock population 11.Others, specify _____

27. What do you think are those important farming system constraints within your area?

1.Climatic unreliability 2.Bush encroachment 3.Shortage of water 4.Shortage of pasture 5.Low input use 6. Lack of fair access to market 7.Lack of improved technology 8.Labour

constraint 9.High stocking rate 10.Soil fertility decline 11.Soil erosion 12.Livestock disease 13.Others, specify _____

28. Of these, what are the three most important farming system constraints? (Rank them from 1 to 3)

1._____ 2._____

3._____

Support Services (Information, Credit, Extension and Market)

Information Services

29. Do you have access to up-to-date information on weather/climate? 1.Yes 2.No (Go to Q34)

30. If yes, what is your source of weather/climate information?

1.Radio forecasts 2.Extension agents advise 3.Traditional early warning systems 4.Relatives (social capital) 5.Natural indicators 6.Farmer-to-farmer extension services 7.Other, specify _____

31.If yes, what climate/weather information or forecasts do you access? 1.Short range(day to week) forecast 2.Long range/seasonal forecast 3. Others,(Specify) _____

32. If yes, how often do you access each of the forecasts? 1.Regularly(daily/weekly) 2.Occasionally 3.On-demand basis 4.Others, _____

33. Is the quality of information good enough to prompt you to make farming decisions?

1.Yes 2.No 3.Not sure

Credit Services

34. Do you have access to credit services for your farm business? 1.Yes 2.No (Go to Q37)

35. If yes, which source is it from?

1. Commercial banks 2. Government lending 3.Cooperatives/Unions 4.Social networks 5.Relatives 6.Saving and Credit groups 7.Others, specify _____

36. What is the interest rate in %? _____

Extension Services

37. Do you have access to extension services? 1.Yes 2.No (Go to Q39)

38. How often are they received? 1.On-demand 2.Regularly 3.Occassionally

Markets (Input and Output)

39. Do you have access to **input** markets? 1.Yes 2.No (Go to Q42)

40. What kind of agricultural inputs do you get from the market? 1.Fertilizers 2.Seed (crops and pasture) 3.Chemicals (Pesticides and herbicides) 4. Drugs for livestock 5.Salts for livestock 6.Others, specify _____

41. How far and how long it takes with the mode of transport you usually use? _____ kms/_____ Hr(s), respectively (Mode of transport _____)

42. Do you have access to **output** markets? 1.Yes 2.No (Go to 45)

43. What kind of products do you take to the output market? _____

44. What distance is from here, and how long it takes with the mode of transport you usually use? _____ kms/_____ Hr(s) (Mode of transport _____)

Income Source of the Household

45. What is/are your main source(s) of household income (in order of importance)? 1.Crop sale 2.Livestock sale 3.Off-farm income 4.Relatives support 5.Community support 6.Others, specify _____

46. If off-farm activities are used as income sources, indicate which one do you use?

1.Casual work 2.Sale fuelwood/charcoal 3.Traditional mining 4.Pitty trade 5. Brokering 5.Other, specify _____

47. What was the estimated total annual **off-farm** income of the Household in 2010/2011 (2003 EC) production year? ETB_____ ($US_____)

48. What was the estimated total annual **farm** income of the household in 2010/2011 (2003 EC) production year? ETB_____ ($US_____)

49. In ten years from now do you think you will be? 1.Better off 2.Same 3.Worseoff 4.Difficult to predict

C. Perception of Climate Change

50. Do you perceive/think the climate has changed over the last 20 (twenty) years in your area? 1.Yes 2.No (Go to Q62) 3.Not sure

51. If yes, do you regard the 20 year change in climate as: 1) noticeable but not substantial 2) noticeable and having some effects on agriculture 3) substantially effecting agriculture 4) completely changing the way we farm

52. If yes, why do you think the climate is changing? 1.God's curse 2.Deforestation 3.Natural process/Normal trend 4.Others, specify _____

53. How would you describe the overall trend in climatic conditions? 1.Becoming wild 2.Becoming more unpredictable 3.Becoming better 4.Becoming worse 5.Others, specify _____

Temperature

54. If yes to **Q50** (perceived changes), do you think the temperature is changing? 1.Yes 2.No

55. If yes, which direction is it changing?

1. Warming 2. Cooling 3. More extreme 4.Not sure

56. What evidence can you mention for this, if you feel it is changing?

56.1 Daily temperature: 1.Increasing (warming) 2.Decreasing (cooling) 3.Not sure

56.2 Nightly temperature: 1.Increasing (warming) 2.Decreasing (cooling) 3.Not sure

57. Which season do you think is changing more in terms of temperature? 1.Ganna (Long rains) 2.Hagaya (Short rains) 3. Boona Hagaya (Long dry) 4.Adolessa (Short dry)

Rainfall

58. If yes to **Q50** (perceived changes), is the rainfall changing? 1.Yes 2.No 3.Not sure

59. What aspects of rainfall characteristics did you see changes in? 1.Amount 2.Intensity 3.Seasonal distribution

58.1 Amount: 1.Increasing 2.Decreasing 3.Not sure

58.2 Intensity: 1.Increasing 2.Decreasing 3.Not sure

58.3 Timing: 1.Early onset 2.Late onset 3.Not sure

58.4 Duration: 1.Longer 2.Shorter 3.Not sure

60. Do you think this year's rainfall is different from others in the recent past? 1.Yes____ 2.No____

61. If seasonal change is happening, which season do you think is changing most?

1.Ganna (Long rains) 2.Hagaya (Short rains) 3. Boona Hagaya (Long dry) 4.Adolessa (Short dry)

Extreme Weather Events and Climate Hazards

62. Which extreme weather event is common in your area?

1.Drought 2.Flooding 3.Heatwaves 4.Hail-storms (Strong wind) 5.Disease outbreak (livestock) 6.Disease outbreak (Human) 7.Conflict 8.Others, specify _____

63. Which climate hazard is more threatening to your livelihood?

1.Drought 2.Flooding 3.Disease outbreak (livestock) 4.Disease outbreak (Human) 5.Conflict

6.Others, specify _____

64. Which immediate impact of climate change is frequently observed in your area?

1.Drying water points 2.Drying pasture 3.Crop failure 4.Livestock death 5.Others, specify _____

65. Which immediate impact of climate change is more threatening to your livelihood?

1.Crop failure 2.Drying water points 3.Drying pasture 4.Livestock death

5.Others, specify _____

D. Adaptation and Risk Management Strategies

66. If you say yes to **Q50** (perceived changes), did you respond to and take any adaptive measures?

1.Yes 2. No (Go to Q68)

67. If yes, what is the most frequently used and effective adaptation strategy you used to respond to climate variability/change during the last 20 years period? (Pick three and Rank them).

a. Sale of livestock	f. Off-farm employment
b. Herd diversification	g. Take part in social safety nets (which one? _____)
c. Herd mobility	h. Seek relatives support
d. Water development	i. Supplementary livestock feeding
e. Cultivation of crop(s)	j. Other, specify _____

Barriers to Adaptation

68. Do you think there are constraints/barriers to adaptation? 1.Yes 2.No

69. If yes, what do you think are those barriers for adaptation to climate change?

1.Lack of climate information 2.Shortage of financial resources 3.Shortage of labour 4.Shortage of land 5.Lack of access to irrigation 6.Lack of policy support 7.Lack of overall support from government 8.Lack of knowledge 8.Others, specify _____

E. Rural Institutions

70. Do you have community based rural institutions such as *Konfi* (water committee) and *Busa Gonofa* (financing) that involve in adaptation in your area? 1.Yes 2.No

71. If yes, are you involved in these community based institutions? 1.Yes 2.No

72. Are you a member of the leadership in these institutions? 1.Yes 2.No

73. On what kind of knowledge do you depend for your adaptation measures? 1.Indigenous measure 2.Expert knowledge 3.NGO recommendation 4.Guildeline and manuals 5.Others, specify _____

- ***Thank you for taking part in this interview! -***

Validation:

Enumerator's name: _____

Signature:_____ Date: _____

Appendix ii. An interview schedule for institutional leaders on institutional aspects of climate change adaptation

(Rural institutions issues and indigenous knowledge - 8 Interviews)

Questionnaire II - Institutional Leaders (8 Interviews)

Identification number (code): _____

Date of interview: _____/____/____

Name of respondent: _____

Role: _____

Affiliation:_____

District: _____

Production system: _____

Peasant Association: _____

Note: Hello! My name is Nega E Debela. I am hoping that I may be able to spend some time with you asking you about climate variability and change adaptation, and local institutions in your area. My research aims to assist the region and community by bringing into light some of the key issues that need to be addressed by policy makers, researchers and practitioners. Your answers will be confidential and unidentifiable by name, and I shall only present the results in aggregate form. Please don't feel as if you have to answer every question I'm going to ask you.

Declaration of Consent

Having listened to the information on the Information Sheet, I confirm my voluntary participation to this interview.

Yes ☐ **No** ☐ **Signature: _____ Date: _____**

Institutions (Interfaces, Synergies and Trade-offs)

1. Which rural institutions are you aware of that are involved in adaptation to climate variability and change in your community or local area?

_____

_____

_____

_____

_____

2. What kind/category of rural institutions are involved in climate variability and change adaptation? (Financial, Religious, Cultural, NRM, etc)

_____

_____

_____

_____

_____

3. What is the specific role these institutions play in facilitating effective adaptation of agriculture to climate variability and change?

_____

_____

_____

_____

_____

4. How is/are your rural institution/s *interacting* with the relevant formal government and non-governmental institutions and structures in your area?

_____

_____

_____

_____

_____

5. What **synergies** do these rural institutions create by interacting with existing formal government and non-governmental institutions and structures?

_____

_____

_____

_____

_____

6. What **tradeoffs** and **conflicting outcomes** do these rural institutions create by interacting with existing formal government and non-governmental institutions and structures?

_____

_____

_____

_____

_____

Public Policy (Strengths and weaknesses)

7. How do you see government **approaches** and/or **policies** towards managing risk and adaptation to climate variability and change in agricultural sector?

_____

_____

_____

_____

_____

8. What do you think are the **strengths** of current government policies, programmes and approaches to climate variability/change adaptation and risk management in agriculture in your area?

_____

_____

_____

_____

_____

9. What do you think are **weaknesses** of or **gaps** in current government policies and programmes in dealing with climate variability/change adaptation and risk management in agriculture in your area?

_____

_____

_____

_____

_____

Indigenous Knowledge

10. Do you think there exist sound **indigenous knowledge** supporting adaptation to climate variability and change in agriculture in your area? Yes No

11. If yes, which indigenous knowledge or practice and how do you make use of them?

_____

_____

_____

_____

_____

12. If not, why?

_____

_____

_____

_____

_____

13. How do you **compare** the importance of this indigenous knowledge with the expert knowledge you receive through extension services or other means?

_____

_____

_____

_____

_____

14. Any more comments you would like make,

_____

_____

_____

_____

_____

Validation:

Interviewer's name: _____

Signature: _____

Date: _____